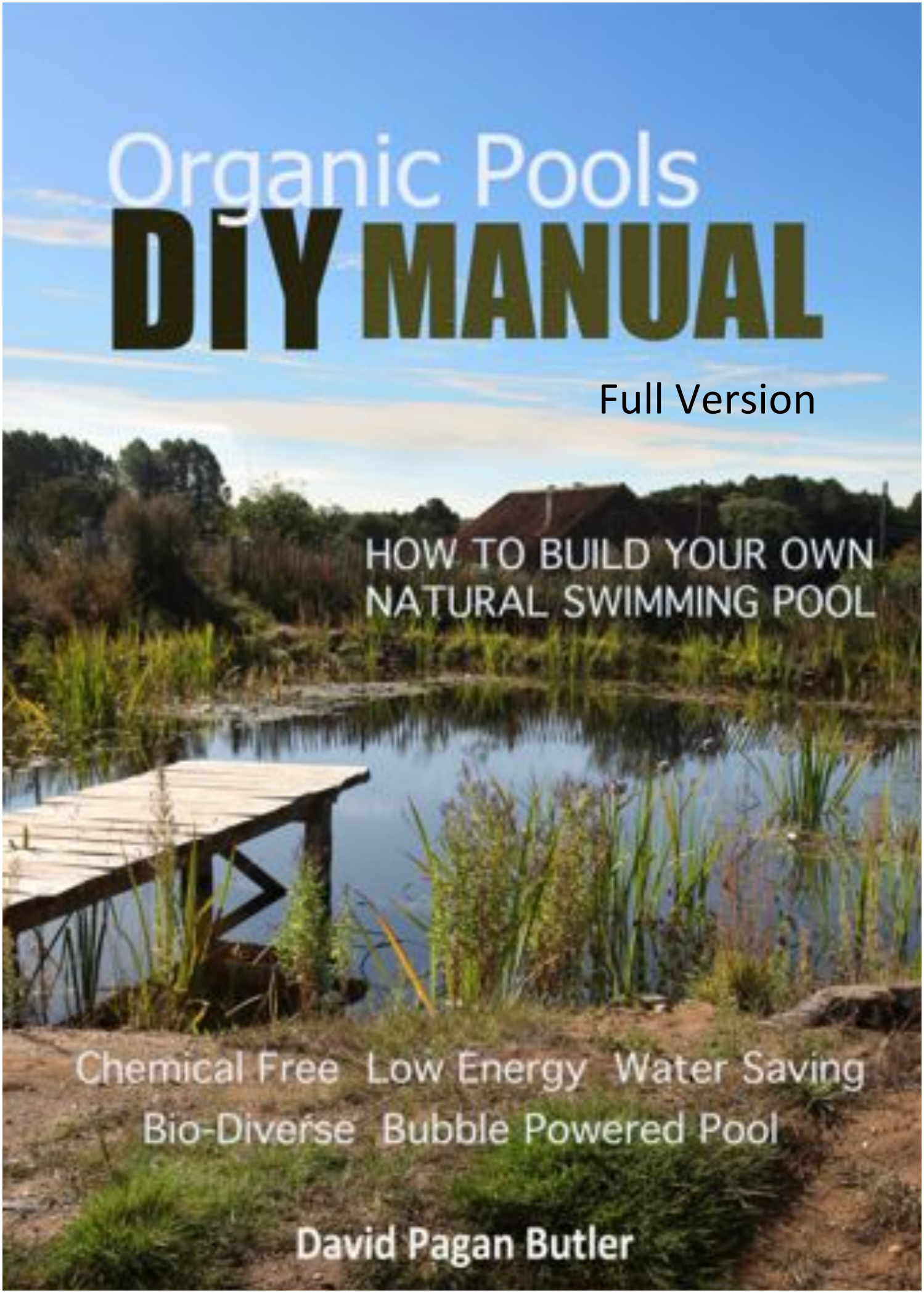
Organic Pools
DIY MANUAL
Full Version
HOW TO BUILD YOUR OWN
NATURAL SWIMMING POOL
Chemical Free Low Energy Water Saving
Bio-Diverse Bubble Powered Pool
David Pagan Butler

ORGANIC POOLS
DIY MANUAL

By
David Pagan Butler

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The Aim of this Manual

This is a practical step-by-step guide to build your own Natural Swimming Pool. It is designed to accompany my film "Natural Swimming Pools - A Guide to Building your Own" which is available on DVD from organicpools.co.uk

This method of pool building has been devised for any practical person to undertake without having to involve specialist contractors for any part of the project. There are two main projects, a 48m2 organic plunge pool and 180m2 full size pool, both built to the same method. They incorporate reused materials and minimise energy expenditure to reduce the cost to us, and the environment.

In the first project we will cover every step of pool construction in detail, from beginning the excavation to bubble pump circulation, from crafting a filter with reclaimed materials to building a jetty. Equipped with this knowledge we'll see how to go on to make a full size pool.

There are many ways of creating a Natural Swimming Pool, but I want to show you a way that is simple to construct and works perfectly. From there, you can adapt it to fit in with your own ideas. This is a practical guide to get more of us started on building these pools. To date, there is no-other publication that provides this information. Indeed there are many people who would have you believe this is too complicated for the non-professional. That is nonsense. I want to show that this project is hard work but deeply rewarding and completely achievable, and along the way we'll bubble a few more myths out of the water.

Introduction

Why do we smile, or for some of us, struggle to contain our gushing beams of joy, the first time we see a natural swimming pool? Is it because inside we know this is so right, giving something back to nature by the creation of a small wilderness? Perhaps we have always secretly wanted to jump into deep luscious pools of freshwater but have been frightened off by decades of myths listing battalions of hazards awaiting any adventurous swimmer.

Today, flourishing on a tide of awareness, we see living freshwater with fresh vision. Thankfully now, we can jump in as happily as an otter.

A Natural Swimming Pool, or as I prefer to call them, Organic Pool, has got to be the most magical addition to our home. It is a beautiful place to observe nature throughout the seasons, bringing us closer to wildlife. The multitudes of species that now live in the pond are an endless fascination to my children, who spend hours observing them from the small jetty which traverses the shallows, dangling down their nets to catch water-boatmen or dragonfly larvae for a close-up look at these incredible creatures.

Then come the birds, visiting the pond in the morning and evening. The grey wagtails, skylarks, dunnocks, gold finches and the formations of swallows circling and skimming the surface to drink or bouncing with delicious splashes to bathe. Dragonflies patrol, snapping up crane flies and cabbage white butterflies and buzzing into skirmishes with intruders. House martins peck at the water's edge collecting mud for nests. Bats flit in and out of their invisibility cloaks in the evening glow reflected on the pond. And sometimes, in the skidding sunbeams of the morning, I may catch the iridescence of a kingfisher feeding on water beetles.

This pond has become another stepping-stone for wilderness. Local native flora and fauna has found its way in and flourished, increasing local biodiversity. And if we create more ponds we will contribute to re-establishing our countryside's diminishing freshwater network.

And of course the swimming! Our children are learning to swim in a healthy environment free from the unpleasant effects of disinfectants found in most pools. I imagine, one day we will look back and wonder how we ever thought it was reasonable to let our children swim in anything other than natural water.

Healthy for our ecology, healthy for us and healthy on our pocket

Until now only people with a fair amount of cash, typically from around £50,000, have been able to consider having one built for them. But there is a different way. I want to show how I built mine, an 180m2 pool, for roughly £6,000 and also another 48m2 pool for £2000. And knowing what I know now, I could do it for considerably less. It takes a lot of work but, after all you'll be saving tens of thousands of pounds by building it yourself, and I can't think of any work more rewarding than creating a pool. I hope after seeing my construction method, the process will be demystified and you'll think it's a project you could happily be immersed in.

Today, diggers and dreamers can make something precious; a little bit of wilderness you can dive into.

How Organic Pools work

Organic Pools (Natural Swimming Pools), work with nature to provide clean healthy water for swimming. Plants and animals in the pond condition the water without the use of chlorine or other disinfectants. So the water doesn't sting your eyes, bleach your skin, corrode your teeth or make your swimming trunks fall apart. Instead, the water holds a vibrant and diverse ecosystem, teeming with micro-organisms that constantly filter and devour any human pathogen that has the misfortune to plop in.

The key to promoting a diverse eco-system is to prevent one species from dominating the pond. In a poorly created pond the usual dominating big baddy is blanket-weed. Blanket-weed (Cladophora superphylum) is the commonest filamentous alga forming dense swathes over ponds in bright warm weather where phosphate and nitrate levels are high. If this happens to a pond, the last thing you want to do is slip on your costume and dive through the bright green slime. But, do not worry, if the pool is made correctly and cared for properly, this will not occur.

The key to control the growth of algae is to restrict the nutrients entering the pool. If the nutrient level is low enough, plants successfully compete with algae. As the plants grow they accumulate the nutrients in their structure and further deprive the algae from flourishing.

As well as plants there are other vital allies – the myriad of micro-organisms that make up the zooplankton living in every cubic millimetre of pond water. A lot of the small pond creatures are commonly called "water fleas", which is a bit unfair because they are not fleas and certainly wouldn't bite. Amongst them are daphnia. These tiny crustaceans are essential to promoting clear water by filtering out, and consuming, suspended particles of algae. We need to look after them. Incidentally, this is the main reason an Organic Pool shouldn't have fish. They eat the daphnia.

daphnia

Algae, will never disappear completely, after all they are wild plants and part of the healthy eco-system, but in a properly functioning pool most of the algae will be confined to the margins or hardly visible at all.

The Structure of an Organic Pool

In the Organic pool, the area is divided into two sections, the swimming zone and the regeneration zone. The regeneration zone contains the plants so is also referred to as the planted zone. The pool in the photograph has the deep swimming zone in the middle surrounded by the planted zone. The planted zone should represent at least half of the total area of the pool, and it is here that most of the water conditioning occurs. The water is circulated, either naturally or mechanically, throughout the whole pool.

If a pool is large enough, with enough deep areas, then it can rely upon natural convection currents and surface wind movement to maintain the water circulation. The recommended minimum total surface area for such a pool is 120 m2. If the pool is smaller, or the regeneration zone proportion of the whole is reduced below half, then there is increasing reliance on technical equipment to provide the circulation and filtration.

The Natural Swimming Pool industry is moving in an increasingly technical direction. Some pools now look very similar to a conventional swimming pool with not a plant or animal in sight. The more technical installations operate on a very similar principle to a rotary sewerage bed. The filtering and water purification is done by a separate biological filter bed containing a porous substrate. This is home to microorganisms that feed on the organic matter in the water. These organisms are reliant on the water being pumped through the filter to provide them with nutrients and oxygen. (If the technical system becomes faulty, these organisms can die off and quickly decay, releasing their nutrients and causing algae to bloom.) Although a frog, or any other potential coloniser will quite happily swim in such a pool without being zapped by chemicals, the pool will do less for biodiversity because it is devoid of native plants and is highly filtered. Pools with local native flora will provide habitat for wildlife as well as enhanced natural water quality resilience.

Pool Construction Design Considerations

Choosing a site for the pool

A healthy pool needs just two ingredients, water and light. Provide clean water, preferably rainwater, and plenty of sunshine then nature will dive in and do the rest. Pond plants grow best in full sun. Water lilies need around six hours of sunshine to fully flower. And people prefer to be in a sunny place with some shade to shelter in the heat. Shade can easily be created, whereas, creating sunshine is trickier.

The location of the pool is mainly determined by those needs but other practical issues may influence the decision such a drainage or access.

Swimming safely

The main difference between a pond and an Organic Pool or swimming pond is having a swimming zone that can be kept free from weeds and sediment. The big reason for this is safety. Swimmers need to be visible at all times, especially children. Swimming in a wild pond can stir up sediments from the bottom and quickly reduce the water visibility to zero. If the pool is deep, although disturbing the bottom is less likely, the lower levels of water can be extremely cold which is another hazard.

A swimming pond, with a smooth bottom to facilitate cleaning and a depth of around two metres is a far safer way to swim. Gently sloping beaches around the pool reduces the possibility of a child tumbling into water too deep for him to cope with. And most importantly, the pool needs a good fence to prevent unattended children gaining access.

Embodied energy

This is a measure of fossil fuel energy, and hence environmental cost, required to produce construction materials. I have tried to choose materials and methods with an eye to reducing the amount of embodied energy involved in the pool construction. The secondary benefit of trying to minimise the use of high-energy materials is the reduced expense. Low embodied energy materials are usually cheaper.

Historically pools have been lined with puddled clay. A clay liner has the lowest embodied energy, but if we consider the transport for the huge amount of clay needed and the effort involved making it watertight then it becomes impractical for most of us. The only realistic alternative is a synthetic pool liner. However this is expensive in embodied energy, and consequently cash.

With this as a given energy expense, the aim is to make reductions with the other materials needed for the construction. Cement is another big consumer of energy, so an obvious target to for energy saving. Hence, reducing the amount of cement used on the project has been the main method for controlling the embodied energy budget..

Warming the water

In Austria and Germany, where these pools have had the longest tradition, their summers are usually consistently sunny, and compared to the UK, hot. A big reason for them having an Organic Pool is having relatively cool water to dive into. Their summers can raise the water temperature to 30 degrees centigrade, which is too warm for comfortable swimming and not beneficial for the pond ecology. (If this is the case, deeper pools, three metres or more can be built. The deeper water keeps the water temperature from rising too quickly). Here in the UK we have different weather. In fact, we have very unpredictable weather. It changes, from day to day and hour to hour. Consequently, we hardly, if ever, have too much heat to make water in an outdoor swimming pool too hot to swim in. In fact, let's be honest, it's unheard of. Here in the

UK, the conventional bright blue tiled outdoor pools are usually a bit too cold. So, these outdoor swimming pools quite often have pool heaters. When energy was cheap, pumping heat into water only to let it radiate into space or into the ground seemed reasonable, but not now.

Solar heating

On the face of it, installing dedicated solar thermal panels to heat the swimming pond water seems sensible but let's think this through for a moment. Even if the panels cost nothing to install and were 100% efficient at collecting and delivering the heat, the hot water still ends up in the pool. The regeneration zone is doing that already; turning the sun's radiation into warm water. If we want more solar energy to contribute to the water temperature, then we just make the regeneration zone bigger and let the pool's circulation system draw it to the swimming zone. And that way, we have a bigger nature reserve as well. Once the warmer water is in the swimming zone it makes sense to preserve as much heat as possible by reducing the cooling effect from the ground. At 2 metres depth, the ground in the UK is around 11 degrees centigrade all year round, as the water temperature becomes greater than 11 degrees, heat is lost by radiating into the ground. Insulating the swimming zone's floor and walls reduces this heat loss so the water temperature has a chance to rise more quickly during sunny periods and cool more slowly on dull days.

For warmer climates the needs are different. The water needs to be restrained from getting too warm so insulation is not used as this would reduce the welcome loss of heat into the ground. The water depth for the swimming and planted zones can be increased to increase the volume to surface area ratio and relatively reduce the effects of solar heating. Shading the pool can further regulate the solar energy input into the water.

Slope

If the site slopes then it is best for the pools length to follow the contour of the land. This will minimize the amount of banking up needed on the lower side to keep it level. When it rains, surface water run off from the pond's surroundings should not be allowed to enter the water. The water will take up chemicals from the topsoil including plant nutrients, or worse still, artificial fertilizers. If these stream into the pond water, algae will flourish and blanket the pond, stealing the sun to kill off other plant competitors. Most of the uphill run off water can be deflected away from the pool with a crescent shaped berm (small bank) made from some of the soil from the pool digging.

Trees

Trees look pretty around the pond but having them nearby can shade the water and inhibit aquatic plant growth. Also, tree roots may grow under the pool and disturb the pond lining.

Leaves falling onto the pond will bring in nutrients and if excessive will disturb the pools biology to the benefit of algae. However, nets can be strung over the pool in autumn to catch most of the leaf litter if trees are nearby.

Access

The machinery for the construction will need access to the site and ample space to maneuver. Commercial Natural Swimming Pool installers usually demand a greater

space for access because they use much larger machinery. They aim to get the job done quickly and therefore maximise their turnover and profits. As a self-builder, you have a far greater flexibility to work within a space that some commercial installers would dismiss as impossible.

Planning permission

Before you start, you should talk to your local planners to see if you need to apply for permission. Normally for the UK, ponds are not an issue with planners, but it is important to check.

This beautiful example of an Organic Pool shows the flexibility of the concept. It was self-built by Bill after he attended an Organicpool.co.uk course. A "professional" Natural Swimming Pool installer had told Bill it was impossible to have a pool in his garden. A second company said they would sell him a DIY kit for £45,000. Bemused by the conflicting advice, Bill spoke to his architect who recommended coming to see me.

During his first day with me Bill experienced something akin to a "Eureka" moment. Almost immediately he started digging and within a few months he had his own pool. It cost him £6,000 saving him £39,000.

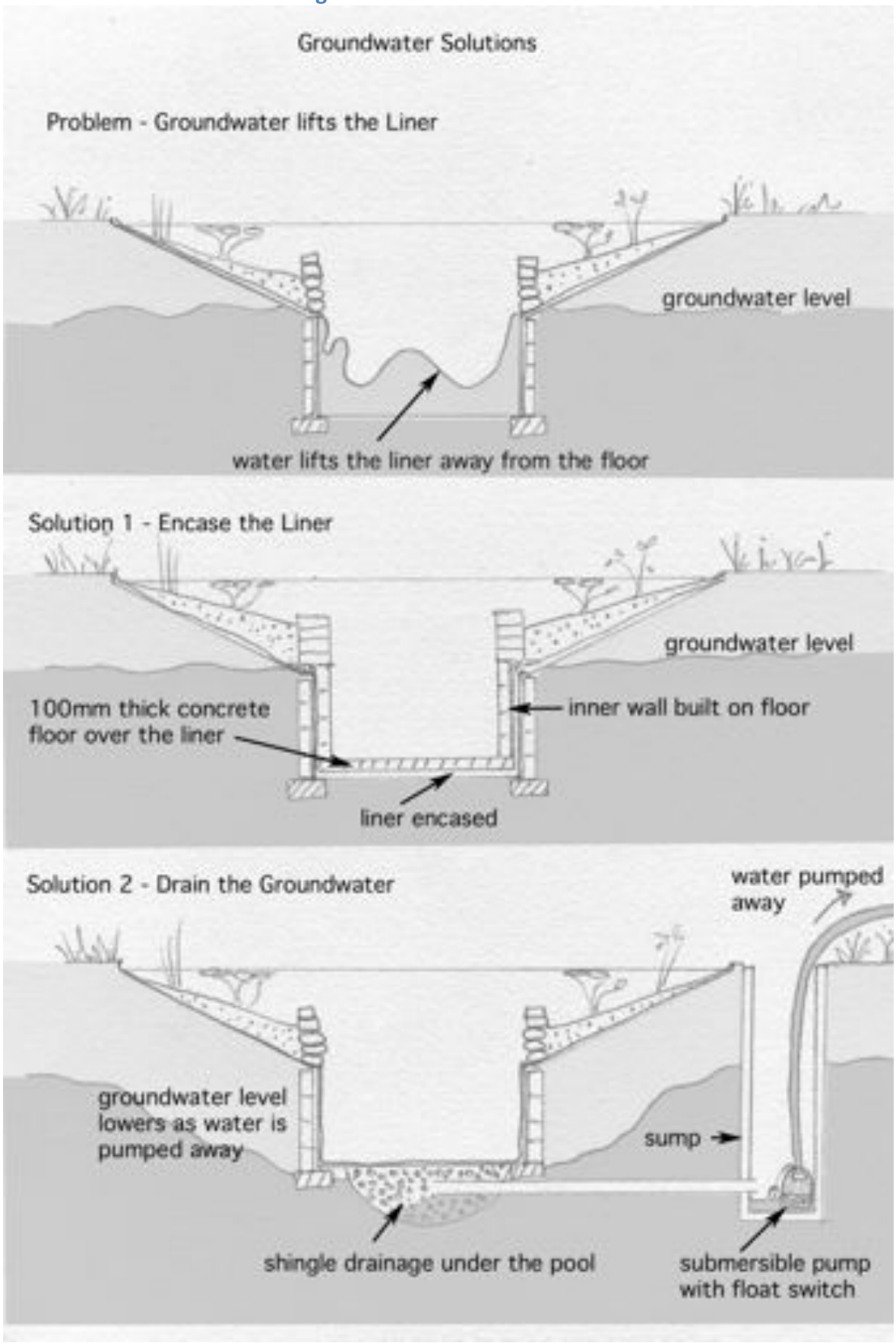
Groundwater

Groundwater is water-saturated subsoil. If you dig a hole through the groundwater level then the hole would slowly fill the hole with water up to that level. In fact, you would have made a well.

The depth of the below the surface of the groundwater level is an important factor for pool building. If the depth of the pool is two metres then the groundwater should never come up to within two metres below the surface. And really there should be quite a healthy safety margin to allow for extraordinary weather or flooding. If the groundwater comes up to meet the liner it can be disastrous. The upward pressure from the ground water can make the pond liner balloon and drift free. When the groundwater level lowers, the liner will drop back down, leaving it creased and distorted and under such pressure it could rip. Any carefully sculpted earthworks below the liner will also be turned to slush.

The groundwater level, or water table, is usually higher in the winter so the site may appear suitable in the summer, only to become a swamp in the winter and liquefy your beautifully shaped pond. If groundwater is a problem then the design must take this into account. There are several options: if the problem is not too severe, a soak away (a gravel bed containing perforated drainage pipes) can be created under the pool. This feeds into a nearby sump, from which the excessive ground water is pumped away. Alternatively, the liner could be encased in concrete at the depths likely to be exposed to the groundwater. Both options require more resources and effort to create so you may be better off forgetting the liner, digging a hole and leaving it to fill naturally. It may not be great for swimming but wildlife will love it.

A recently created wildlife pond fed by groundwater being enjoyed by children in the summer. The water can get a bit murky though.


Groundwater Solutions
Problem - Groundwater lifts the Liner
groundwater level
water lifts the liner away from the floor
Solution 1 - Encase the Liner
groundwater level
100mm thick concrete floor over the liner
inner wall built on floor
liner encased
Solution 2 - Drain the Groundwater
water pumped away
groundwater level lowers as water is pumped away
sump
shingle drainage under the pool
submersible pump with float switch

Organic Pools save water

Because of the buildup of chemical residues in a conventional "blue tiled box" swimming pool, the pool needs to be drained out and the water changed from time to time. The water in an organic pool, on the other hand, never needs to be changed because it is constantly being maintained by the pool's ecology. This equates to a huge saving in precious water resources.

Also, the pond can be constructed to take a greater depth of water than the 2m needed for swimming, say 2.3m. At times of plenty of rain, it can fill to this level and have enough reserve not to require topping up throughout leaner times. With this approach, I have managed to maintain the swimming zone to the 2m minimum depth by feeding the pool entirely with roof rainwater. Also, if needs be, the pond can store water for the garden in times of drought.

Wildlife friendly

All the animals in the pool arrive independently. The pool is designed with gently sloping beaches and combined with periodic changes in water level, these provide flora and fauna with more opportunities. Marginal plants, emergent grasses and sedges growing along the edge of the pond provide cover for animal access into and out of the water.

Low energy consumption

Until recently energy consumption has been of little concern to Natural Swimming Pool installers so few have questioned the need for so much power to circulate the pool water. A typical power rating for a swimming pool pump is 500Watts. However my system using an aquarium air pump can move more than five cubic metres of water per hour, which is perfect for a pool, and it needs only 60 Watts.

Bubble Pumps

I chose to go against the flow with my choice of pool pumping method. Indeed, my pool circulation system seems to be unique, certainly in the UK. I use bubble pumps (or air lift pumps) for my pools. Bubble pumps are used in dredging ships, aquarium filters, and except for some sewerage systems, not much in between. Which is remarkable because bubble pumps have a whole list of advantages.

Zooplankton friendly.

Bubble pumps are gentle. The pool is complex eco-system kept clear by a myriad of tiny organisms constantly filtering the water for organic matter. We need to care for them as they maintain the hygienic quality of the water. Bubble lift pumps can move large volumes of water but at a very low pressure, harmless to aquatic life.

On the other hand, nearly all Natural Swimming Pools use conventional swimming pool pumps. They are not designed with consideration for any life that may have the misfortune to be thrashed through the impeller and terminate in the filter. Problems, such as algal bloom, can occur with the over pumping of these systems because the creatures that filter the water for us have been liquidized.

This advantage alone is enough to justify using bubble lift pumps but there is so much more they offer.

Self-build suitable

The plumbing is simple. The pipes are standard domestic plastic pluming fittings, and so are readily available. They just push-fit together and the pipe is easy to cut. (With a craft knife or a special plastic pipe-cutting tool which costs around £15). And there is no need for an accredited electrician to install the pump as the compressor just plugs into a standard mains socket.

There are many models of aquarium air pump available. Some use a piston system, this model uses the more common diaphram system.

This 60 Watt aquarium air compressor can deliver 4800 litres per hour of air. It is rated to water depth of 3 metres of water but at this depth the volume of air is almost zero. At 2.2m depth it delivers around 1500 ltr/hr. It cost around £90.

Electrically Safe

There are no electric cables in or near the pool. Just plastic pipe delivers the compressed air to the bubble pumps in the pool. And the air compressor is far easier to maintain than a swimming pool pump. It is more easily accessible; not being bolted to the bottom of a pumping chamber and it can't get blocked up with sediments drawn from the water. All it pumps is clean air

How bubble pumps work

Bubble Pumps are also called Air Lift Pumps. Pumping air into water makes bubbles. The bubbles are a mixture of air and water, which is less dense than just water alone.

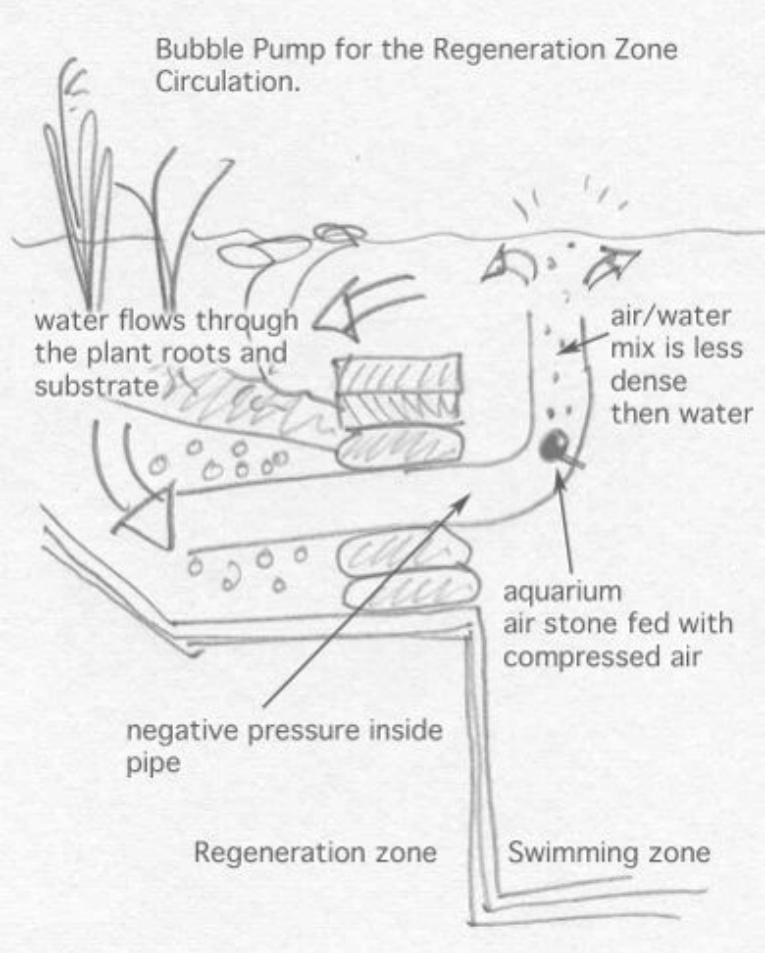
A bubble pump demonstration in a jar.

An aquarium air-stone is fed from an aquarium compressor. Bubbles and water flow over the top of the pipe. Water is drawn into the bottom of the pipe.

Being less dense, it will effectively float to the surface as the surrounding denser liquid displaces it. If the bubbles are introduced into a pipe, then the upward flow is capable of pumping large volumes of water but at low pressure (low head above water, typically 15cm). This means they don't consume much power.

Most conventional pumps found in swimming pools and natural swimming pools have fast rotating impellors driven by an electric motor. They can deliver a high head of pressure (10m upwards) at moderate volumes, which is great for fountains and waterfalls, but not for gently circulating a living body of water. And they consume, typically, 500 Watts. Alternatively, an air compressor capable circulating an equivalent volume of water would consume around 60 Watts.

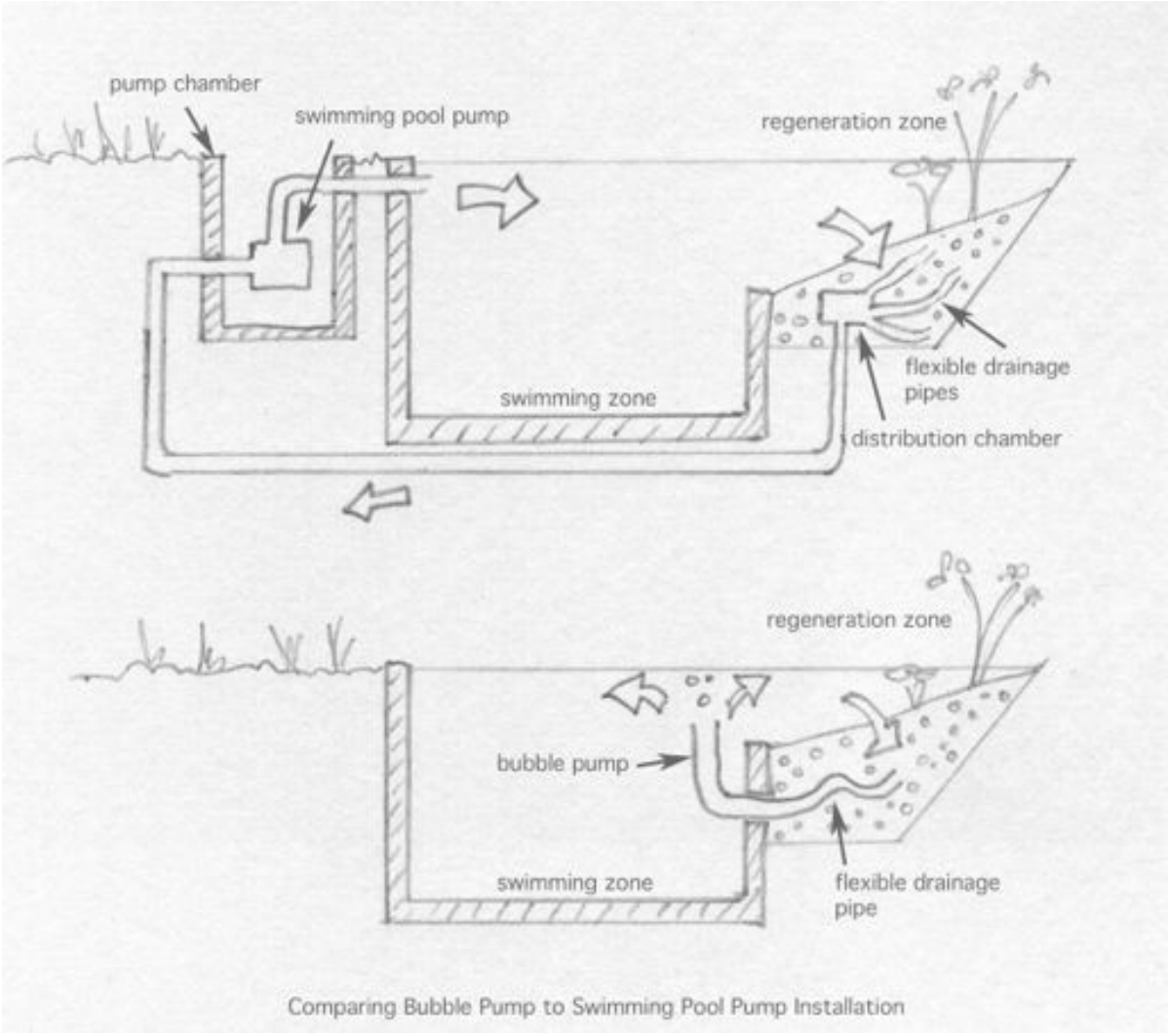
A conventional swimming pool pump used in a Natural Swimming Pool. (Not mine).


Bubble Pump for the Regeneration Zone
Circulation.
water flows through the plant roots and substrate
air/water mix is less dense then water
aquarium air stone fed with compressed air
negative pressure inside pipe
Regeneration zone
Swimming zone

This Bubble Pump consists of a couple of lengths of 110mm dia. standard drainage pipe and a 90 degree bend fitting.

The upward flow of bubbles draws water through the pipe and through the planted zone. This increased water circulation amongst the roots helps the plants and associated micro-organisms mop up the nutrients from the pool water.

This bubble pump has a 50mm dia. aquarium air-stone fitted to the inside of the end cap. This pushes in the bottom of the 110mm dia. drainage “T” fitting. A 6mm dia. plastic aquarium air-line pipe pushes onto the air-stone’s nozzle.



Comparing Bubble Pump to Swimming Pool Pump Installation

The top drawing shows a typical configuration for a Natural Swimming Pool. The conventional swimming pool pump has two conflicting needs; firstly it can only function when it is below the water level of the pool; secondly, it is powered by electricity so it needs to be kept completely dry. A separate pump chamber has to be built near the pool below water level, along with the associated ground works for the pipework (usually 50mm dia. PVC) to the pool. The relatively high velocity of the pumped water can damage the essential microorganisms in the pool. (Incidentally, the direction of water flow in the system is not consistent between installers.)

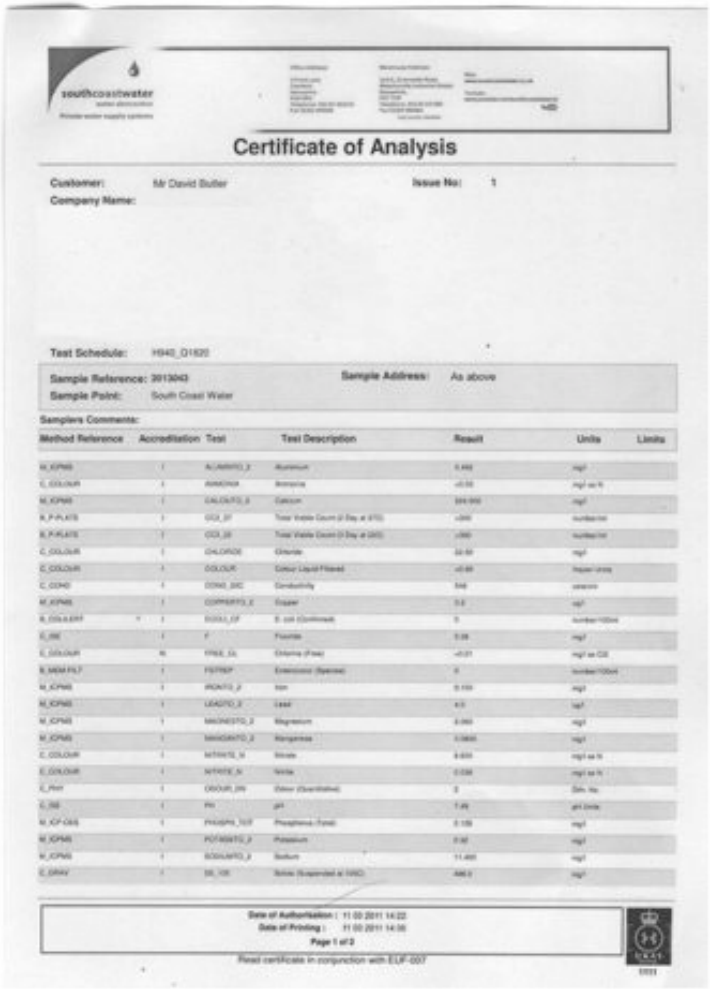
The lower drawing shows my bubble pump system. The bubbles are fed from an air compressor, mounted above water level and at a convenient distance from the pool. It has no pump chamber. Consequently, it has none of the associated long water pipe runs, so it is inherently energy efficient. (As water travels through a pipe it loses energy due to friction. The smaller the diameter and longer the length, the more energy is lost). The bubble pump draws water directly from below the regeneration zone and as the pipework is a minimum of 100mm diameter the equivalent volume of circulated water is pumped at low velocity. This not only harmless to the ecology of the pool, it is also extremely simple to implement.

Water

The quality of the water has a massive impact on the biology of the pool. It may at first sight seem counter intuitive but a wet site that may already have seasonal ponds is not a good place to build a pool. Firstly, you may destroy an existing delicate ecology. Wetlands have been decimated throughout our landscape, three quarters of them have disappeared over the last century, and so we shouldn't contribute to the loss. Secondly, ground water quality is incredibly variable and potentially contains leachate from gardens or farmland laced with artificial fertilizers and pesticides. Indeed, many countryside ponds are in a terrible state because of modern farming practices. Often layered in blanket weed, gorging on the artificial levels of phosphates that have found their way in. An organic pool should not be exposed to groundwater or surface water that has run in from around the pool. Both of these sources are too unpredictable. Commercial installers fill up their client's pools with tap water. But this is also prone to problems. In the UK phosphates are added to the drinking water to inhibit pipe corrosion in the water distribution network. Although harmless to drink, (one would hope), it is a fertilizer for plants. The plants that quickly grab the opportunity are algae or duckweed – equally undesirable for a pool. Unlike the other major biological elements - nitrogen, carbon and oxygen, phosphorus has no gaseous state under normal conditions, so has no escape route into the air. It is a problem

you'll always be stuck with. Commercial installers want to build the pool quickly and fill it quickly with tap water. So, at extra cost, they install phosphate filters. These are big tanks, (sometimes filled with iron wool) involving more construction, plumping, pumps, installation costs and consequently more profit for the installers. And all this technology consumes a lot of energy to maintain.

However, there is a simple solution: rainwater. Rainwater contains very few nutrients, providing the right conditions for balanced pool ecology. Letting the pool fill with the rain that falls upon it is the best option but this could take a healthy chunk out of your life waiting. I compromise slightly. All the rainwater that falls on our house is collected and pumped to the pools. It probably has some bird droppings washed in along the way but it works well for me. Even better, it is quite simple to construct devices to divert the first flush of roof water away, reducing the amount of detritus making its way into the pool. It may still take many weeks or months to fill the pool, but if you making the pool yourself, you should find it filling up as you are working on the project.



southcoastwater

Certificate of Analysis

Customer: Mr David Butler
Company Name:
Issue No: 1

Test Schedule: H940_01820
Sample Reference: 2013043
Sample Point: South Coast Water
Sample Address: As above
Samplers Comments:

Method Reference	Accreditation	Test	Test Description	Result	Units	Limits
M_ICPMS		ALUMINIUM_D	Aluminium	0.002	mg/l	
C_COLOUR		AMMONIA	Ammonia	<0.02	mg/l as N	
M_ICPMS		CALCIUM_D	Calcium	104.000	mg/l	
M_P-PLATE		CC3_37	Total Viable Count (3 Day at 37C)	>300	number/ml	
M_P-PLATE		CC3_22	Total Viable Count (3 Day at 22C)	>300	number/ml	
C_COLOUR		CHLORIDE	Chloride	22.50	mg/l	
C_COLOUR		COLOUR	Colour Liquid Filtered	<0.60	Hazen Units	
C_COND		COND_25C	Conductivity	540	uS/cm	
M_ICPMS		COPPER_D	Copper	0.0	mg/l	
M_COLIFORM	Y	ECOLI_CF	E. coli (Confirmed)	0	number/100ml	
C_ISE		F	Fluoride	0.09	mg/l	
C_COLOUR	N	FREE_CL	Chlorine (Free)	<0.01	mg/l as Cl2	
M_MEMFILT		FILTREP	Enterococci (Species)	0	number/100ml	
M_ICPMS		IRON_D	Iron	0.110	mg/l	
M_ICPMS		LEAD_D	Lead	0.0	ug/l	
M_ICPMS		MAGNESIUM_D	Magnesium	6.060	mg/l	
M_ICPMS		MANGANESE_D	Manganese	0.0600	mg/l	
C_COLOUR		NITRATE_N	Nitrate	0.630	mg/l as N	
C_COLOUR		NITRITE_N	Nitrite	0.038	mg/l as N	
C_PHY		ODOUR_DN	Odour (Quantitative)	0	Dilution No.	
C_ISE		PH	pH	7.49	pH Units	
M_ICP-OES		PHOSPH_TOT	Phosphorus (Total)	0.130	mg/l	
M_ICPMS		POTASSIUM_D	Potassium	0.92	mg/l	
M_ICPMS		SODIUM_D	Sodium	11.400	mg/l	
C_GRAV		SS_105	Solids (Suspended at 105C)	486.0	mg/l	

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Read certificate in conjunction with ELF-007

Part of the water test results for the pool.

The laboratory water tests for my organic pool showed, not only was it perfectly safe for swimming, it was good enough to drink. It comfortably exceeded UK drinking water standards in all parameters tested.

The Chemistry of the pool

As the pools are self contained, in terms of water flow they do not do not have a water discharge so all the substances that are introduced into the pond are retained until they are broken down, through biological activity and mineralisation. Organic matter consists mainly of the following elements: carbon (C), hydrogen (H), oxygen (O), nitrogen (N) and phosphorous (P).

Hydrogen, under normal oxygenating conditions ends up as water (H2O). Oxygen, nitrogen and carbon are released as gaseous oxygen, nitrogen and carbon dioxide but there is no gaseous escape for phosphorous. In a natural pond this enrichment of phosphorous leads to an increase in biomass and gradually, over many decades, it can go through a process of succession to become a bog and ultimately, a woodland. Not great for swimming. (Although some natural pools, low in nutrients can last for ten thousand years.) The only way to take phosphorous out of a pond is to physically remove it. Fortunately, that is not so difficult. Trimming back over-grown plants in the autumn and putting them on the compost heap is all that is needed. This effectively reduces the total available phosphorous available in the ecological sphere of our pond. And makes good compost.

Law of minimum –J.llebig, 1862
Plant growth depends on the nutrient minimally present in comparison to all other factors.

Redfield formula: C : N : P = 115 : 15 : 1

In a pond there is plenty of carbon and nitrogen but phosphorous is often in short supply. Under these conditions, phosphorous becomes the controlling factor in determining plant growth and is subject to competition amongst them. When we say the pond should be low in nutrients for balanced conditions and optimal water quality, we usually mean it should be low in phosphorous.

Tapwater usually contains considerable levels of phosphorous, which is added to retain the hardness factors in solution and keep the distribution network free from calcification. In other words, stop the pipes furring up. By adding tapwater to a pond, we introduce unwanted levels of these soluble compounds of phosphorous and provide an opportunity for excessive algal growth. Surface runoff water from the pool's surroundings can also contain phosphorous washed from the soil, so the edges need to be constructed appropriately to prevent it entering the pool. Rainwater falling directly onto pool is the best water for filling and topping up the pool as it contains hardly any nutrients. Roof-water is a close second.

The ecology of an organic pool is formed from the local flora and fauna and the physical and chemical quality of the water.

The water quality can be categorised in terms of nutrient levels.

The trophic class is the measure of the phototrophic production in a standing body of water. Increasing nutrient levels in a pond correspond to the following stages:

Oligotrophic: Few nutients and little phototrophic production with hardly any zoo or phytoplankton. A newly filled organic pool will be in this state but as there is a tendency towards nutrient enrichment, it will soon become mesotropic.

Mesotrophic: Moderate level of nutrients and plankton and moderate plant growth. Most swimming ponds are in this category.

Eutrophic: The water is rich in nutrients and productive supporting many zooplankton, including our friends daphnia. This water may be cloudy early in the year but as the zooplankton becomes more active, filtering the floating algae, it clears. Many swimming ponds are in this category, characterised by very good plant growth.

Hypertrophic: The level of nutrient enrichment is high leading to vigorous algae growth. Algae blanketing the water can kill off submerged oxygenating plants and lead to organic matter rotting under anaerobic conditions. Hydrogen sulfide and methane may develop.

Trophic Class	P-total (µg/l)	Inorganic nitrogen mg/l	pH	Visible depth approx. (m)	Oxygen Content (%)
oligotrophic	<25	<0.4	6-7	3-6	80
mesotrophic	10-30	0.3-0.65	7	2-6	50-100
eutrophic	30-100	0.5-1.5	>7.4	1.5-3	5-40
hypereutrophic	>100	>1.5		0.5-1.5	0-10

Phosphorous in the pool.

Phosphorous is a fascinating element and essential ingredient for life, indeed the double helix of DNA relies on a phosphate ester bridge that binds the helix together. It also has a multitude of other biological functions: energy storage within cells (ATP), calcium phosphate for bones and teeth, exoskeleton of insects, phospholipids in biological membranes. The list is so much longer but we get the picture. Life needs phosphorous.

In a freshwater pool, the other nutrient elements, carbon, oxygen, hydrogen and nitrogen are usually abundant but phosphorous is relatively scarce so its availability becomes the limiting factor to the biological productivity of the pool. It is as if life in the pool has got a kit of parts ready to get growing but it is just awaiting special delivery of phosphorous. It arrives periodically, parcelled up in differing forms reflecting the variety of life around the pool; bird droppings, toad spawn, leaves, pollen, petals, discarded bikinis. The bacteria in the water naturally decompose all of this flotsam and the resulting inorganic nutrients, including phosphorous, are recycled and assimilated into plant growth, maybe even back into flower petals. However, it would be best to pick out a bikini. (A synthetic material may take four hundred years to rot but hidden within the fabric maybe residues of washing powder, which usually contains, guess what … phosphorous.)

The balance of nutrient recycling in the pool, although robust and adaptable, can be disturbed by a shock to the system from a sudden influx of nutrients. This can happen after a downpour of rain if a poorly constructed pool allows run-off water to flow in from the surrounding soil. The rapid intake of nutrient rich water from the soil can overwhelm the pool's ecology.

(Unlike Nitrogen, phosphorous is transported mainly by runoff. This occurs because phosphorus has a high affinity for soil particles and does not leach through the soil column. From this fact, it's easy to see why rainy weather in an agricultural area , or a fertilized garden, can pose a major problem for a pond.)

The pool should be constructed to prevent run-off water entering the pool otherwise the following sequence of events can unroll like a big green carpet.

The soluble phosphates from the soil entering the water primarily benefit the organisms that can react quickly to the opportunity, the filamentatious single celled algae. They quickly multiply, cover areas of water with a blanket of algal growth and suppress the light reaching the submerged plants. The submerged plants can't photosynthesise so they can't grow and compete for the soluble nutrients in the water. The algae, floating on the surface, are sitting pretty in the sunshine. They have light and more nutrients for themselves as they increasingly cover the pool. The submerged plants die and decompose to provide even more nutrients to the water. As these oxygenating plants are killed off, the oxygen levels in the water plummet and consequently the aquatic animals die. This contributes to more organic matter added to the nutrient soup.

Just when you thought it couldn't get any better for the algae, it does. The algae is now so thick the lower layers of the algae die and decompose along with all the other dead organic material in the pool, but because the oxygenating plants have also been turned to mush, the oxygen level in the water is very low and under these conditions, the

This village pond is typical of most ponds throughout our countryside nowadays. It has too many nutrients flowing into the pond causing excessive plant growth. Algae often dominate this pond.

decomposition of organic matter becomes anaerobic. This anaerobic decomposition generates acidic conditions and so the pH of the water drops from being slightly alkali (around pH 7.5) to being acidic (below pH 7). This drop in pH can kick off another sequence involving our key character, phosphorous, entering somewhat unexpectedly from below stage via an unlocked trap door.

The clay rich sediments in the pool contain lots of aluminium. This element is very attractive to phosphorous, so it remains is bound to the aluminium and unavailable as a plant nutrient. But guess what? When the pH lowers the aluminium loosens its grip and the phosphorous slips into the water. Spiking the water with another influx of phosphorous. The water is now so nutrient rich is has become a huge anaerobic digester sealed under a thick blanket of algae. Not the most beautiful of natures creations and not great for swimming. When it gets this bad, no one will need that bikini.

How to Create an Organic Pool

Counter to the conventional wisdom on building Natural Swimming Pools, that pools have to be at least 80m2 to function, I wanted to show that even a very small pool, using my methods, is viable and biologically stable.

I'll show you my building techniques used to create this 48m2 plunge pool. Armed with this knowledge, you'll be able to build a larger pool of any size.

And of course, as I have built these pools myself, the methods I've developed are entirely geared to self-building. No need for professional contractors to fit the liner, plumbing or electrics. Indeed there is no electricity near the pool at all. The pool's novel circulation system is powered by bubbles so it is incredibly quiet, delightful to look at, and completely safe.

This method of pool building works. The water is clean and clear and has been tested to show it even meets UK drinking water standards.

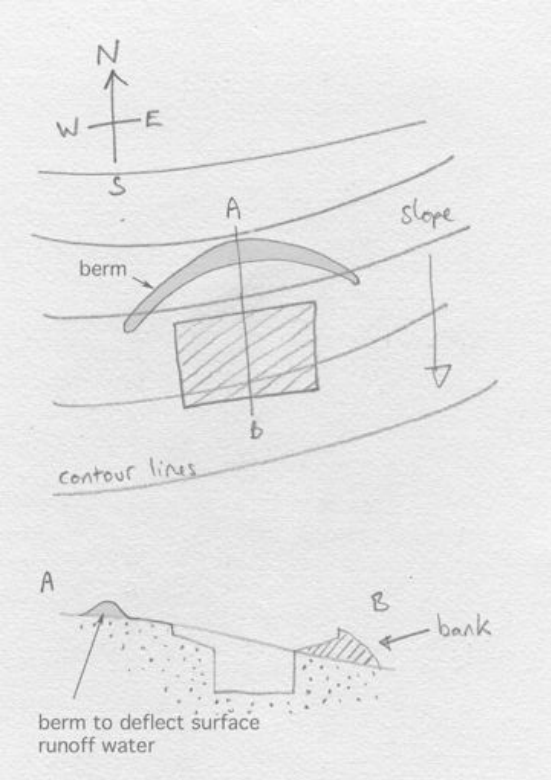
Design Considerations for the Plunge Pool.

The site for this pool is on an open field, which slopes with a gradient of around 10%.

The ground is free draining, with the water table at least five metres below the surface. The subsoil is a patchy mixture of sand, gravel and clay.

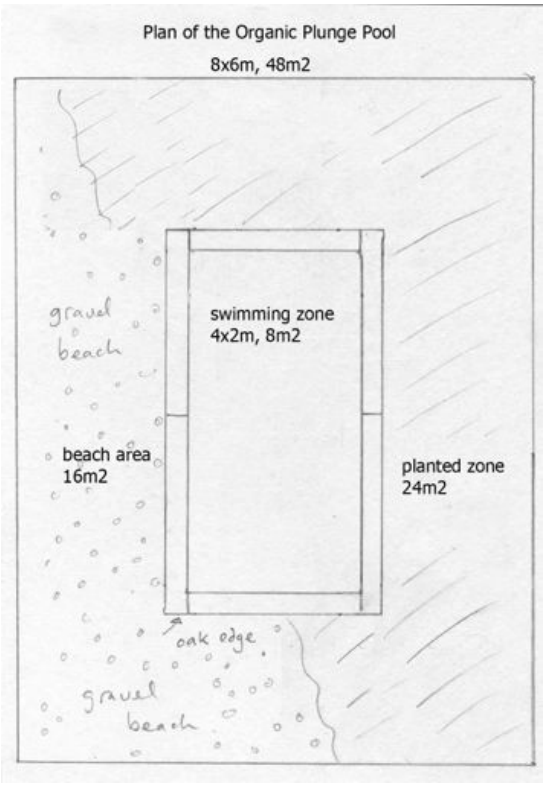
As the pool is on a slope then, banks will have to be built up on three sides (to stop the water running down the slope:).

To minimize the amount of digging and banking up need for the construction, the longest dimension of the pool should follow the contour of the site.

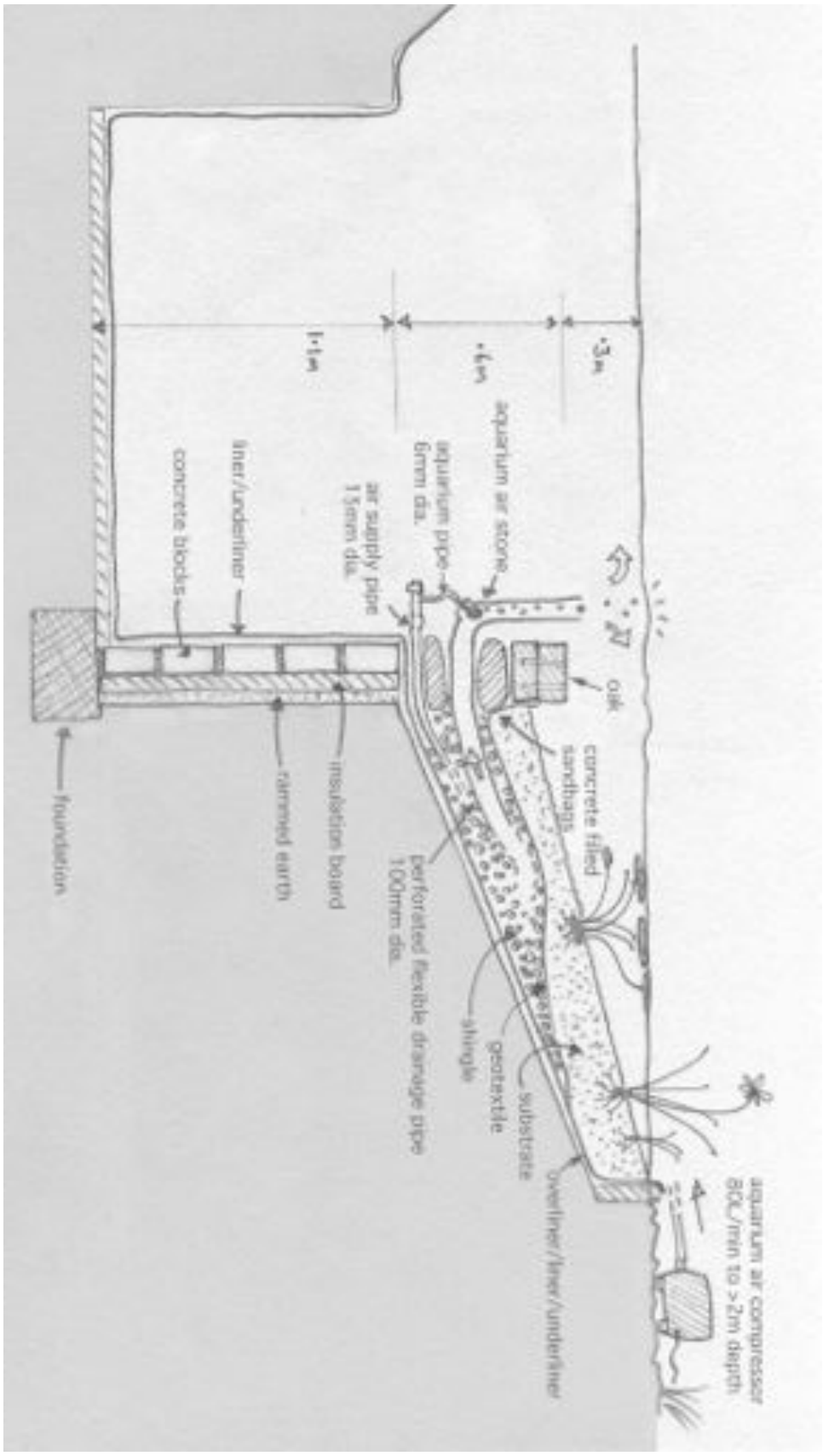


The plunge zone is 2m(6.5ft) wide by 4m(13ft) long and just over 2m deep. The shallow beach area and the planted zone (regeneration zone) will be a border 2m wide, making a total size of 6m by 8m (19.5ft by 26ft).

This is very small for a Natural Swimming Pool. Generally, the bigger the pools are, the more stable the ecology and water quality. This pool is testing the system to the limit.



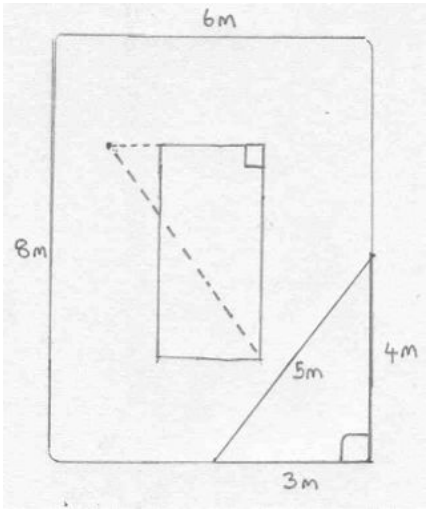
The planted zone is 50% of the total area of the pool. (Beach is classed as swimming zone.)



Cross section of the plunge pool

Tools for pool building

The tool I treasure the most is the mattock. I think this tool should be re-introduced into tool-sheds everywhere.



Three pieces of string, 3m, 4m and 5m lengths define the whole area by building it from the right angle triangles.

Marking Out the Site

I have prepared three lengths of string, 3m, 4m and 5m, each with a loop at each end. They fit over the wooden pegs to easily define their position on the site as the pegs are whacked in. The string is bricklayer's string that doesn't stretch much.

Digging the Swimming Zone

The site is pegged out using the 3,4,5m triangles of string to create the right angles for the rectangular plan.

Normally the topsoil for the whole site is cleared and stored in preparation for the excavation.

Digging with a fork to define the edges of the 4m by 2m swimming zone.

On this site the topsoil was very poor. It had been heavily compacted over the years and the recent weather had been exceedingly dry creating a very hard surface layer. So, I decided to clear the topsoil, not from the whole pond area, but just from the swimming zone (4x2 m).

A mattock is an essential tool for digging through tough ground. After the first couple of feet the digging became easier.

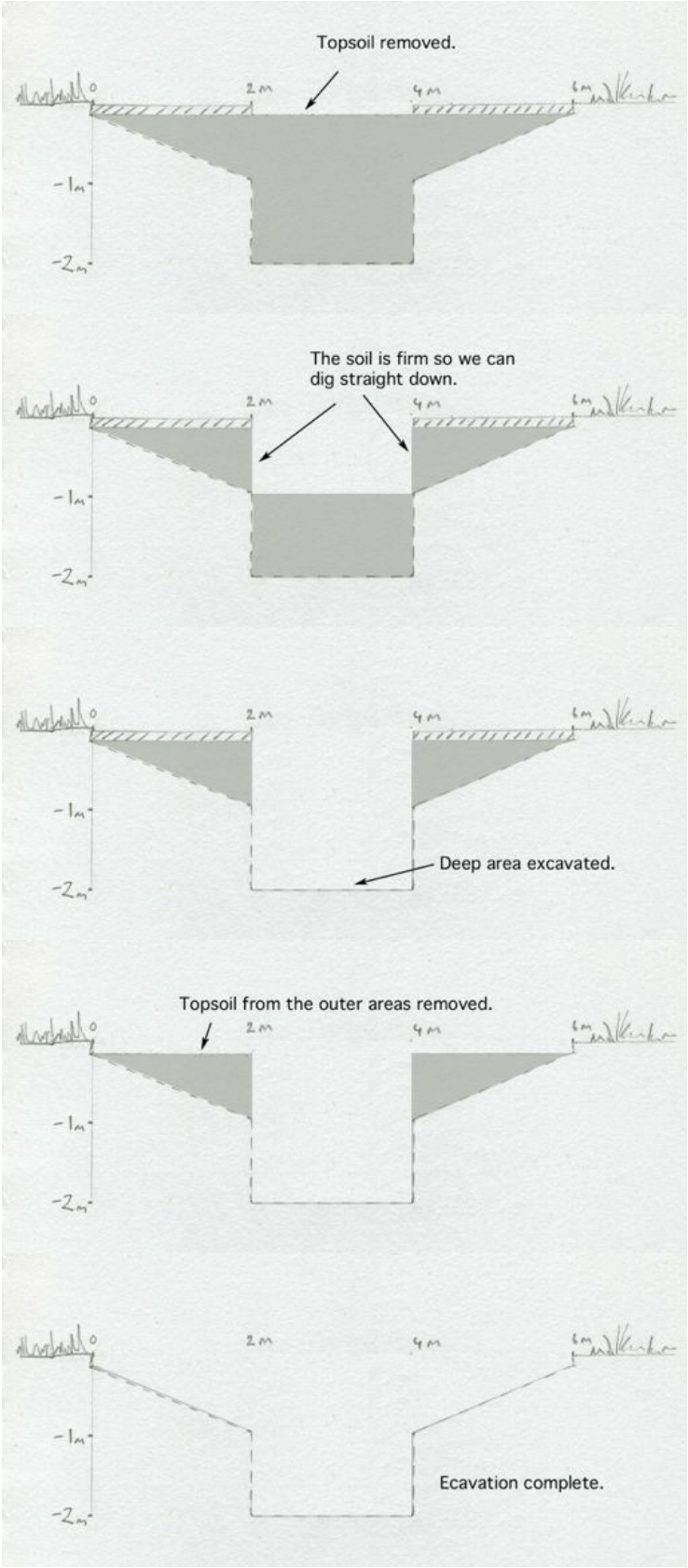
We could then dig straight down to a depth of 2m.

Later, once we had finished building in the swimming zone, we could then take off the rest of the topsoil.

A little old tractor fitted with a backhoe lifts out the bulk of the subsoil.

The topsoil was stored separately in a heap, no higher than 1m to avoid compaction, ready to be used to around the site after completion.

Digging Strategy



The prevailing conditions and the equipment available will determine the digging strategy.

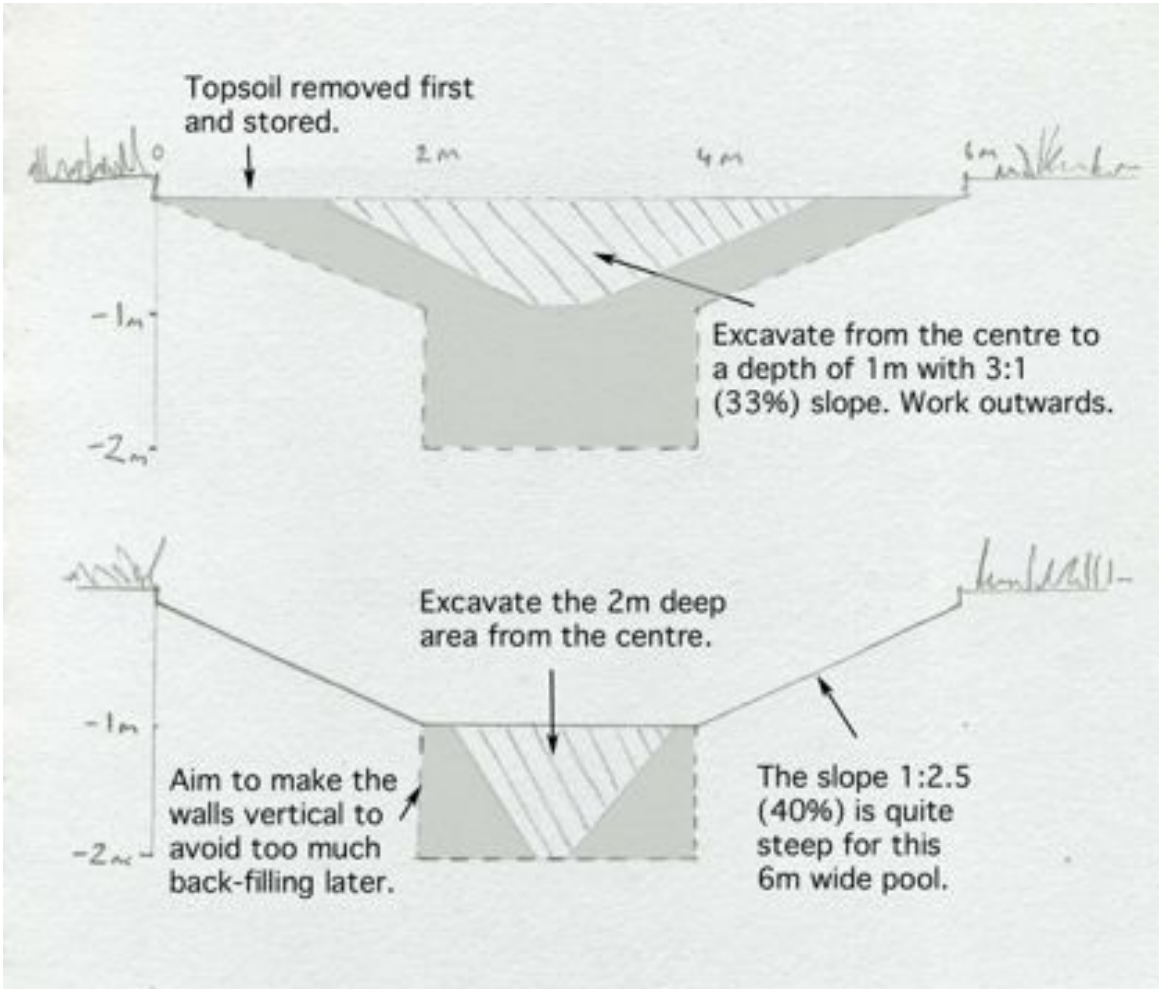
For this project, the soil was firm, the weather dry – well not quite, and my digger backhoe could only reach 2m (6ft6in).

So, I decided to tackle the digging in a slightly less conventional way.

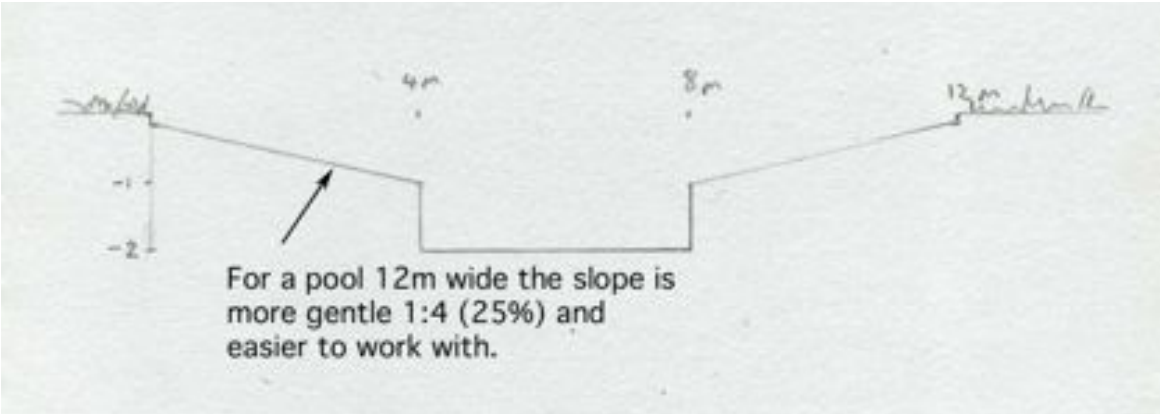
The topsoil was removed from only the area currently being excavated. This was to prevent damage to the upper layers of subsoil surrounding the hole and so make the site less prone to wet weather damage.

As the subsoil was firm it allowed us to dig straight down. The subsoil walls remained vertical and intact.

When the deep area was excavated, the rest of the topsoil was removed, followed by the remaining sections of subsoil.



A more conventional digging strategy is to take off the topsoil from the whole site then start digging from the centre, outwards. Dig down to the 1m level. The deeper area can then be excavated, again from the middle, outwards. If the soil is not firm enough then vertical walls may not be possible and they may have some degree of slope in order to remain stable. This will just mean, after the wall has been built, it will require back-filling and compacting. Building a pool this small does create difficulties; the slope of the planted zone excavation is quite steep. A bigger pool is easier in this respect.



Grading Subsoil

Some areas of the excavation yielded sand and clay, which was separated into heaps.

The 4m by 2m hole is now is now 2m deep. Here the soil is sandy and quite free draining and the water table is greater than five metres down.

The Foundation

The width of a foundation needs to be at least twice the width of the wall it is to carry.

The wall will be made of 100mm thick standard concrete blocks 450 x225x100mm (18x9in). The trench for this foundation is around 400 mm wide, four times wider. (A touch over engineered).

The foundation trench is dug all the way round.

Note the ground is very firm so the walls of earth are sound. If the earth was softer then this method of excavation wouldn't be suitable.

The Bunyip

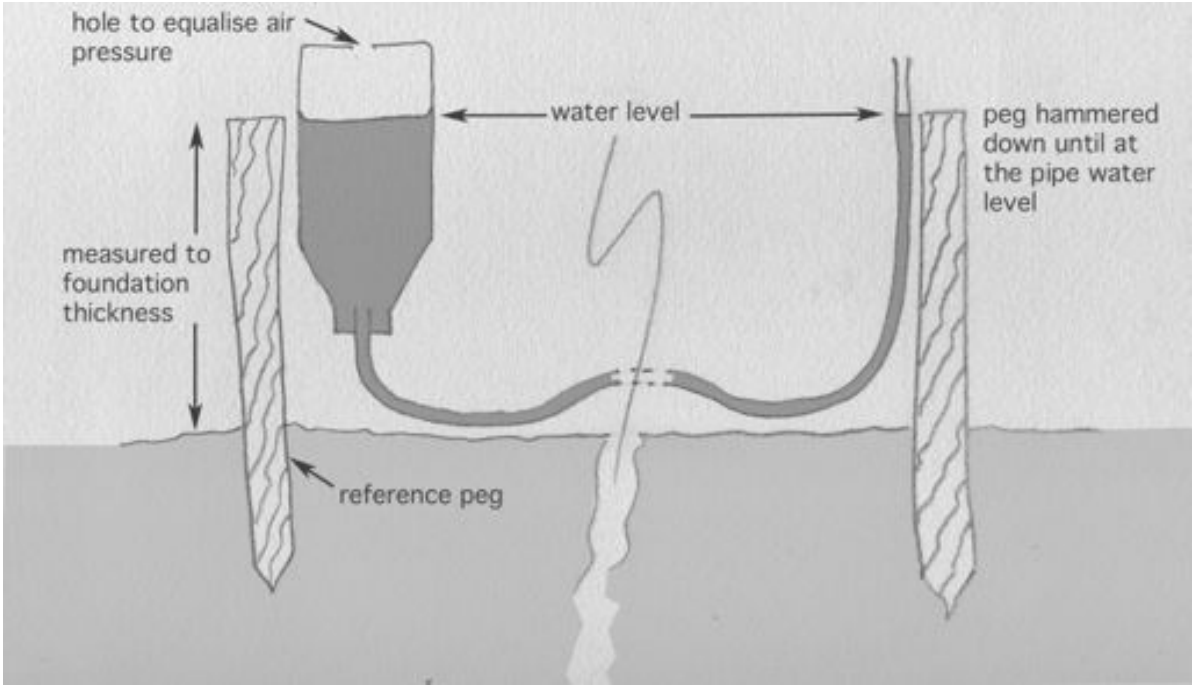
A bunyip is also called a water level gauge. It relies on water's knack of equalizing its level. The bunyip is an upturned bottle connected to a pipe. If both ends are open to atmospheric pressure i.e. the bottle has a hole in the base and no bubbles are in the pipe, then the level in the bottle and in the pipe will be the same.

One end of a 5m length of 6mm dia. aquarium air pipe is pushed through a 5.5mm hole made in the bottle cap.

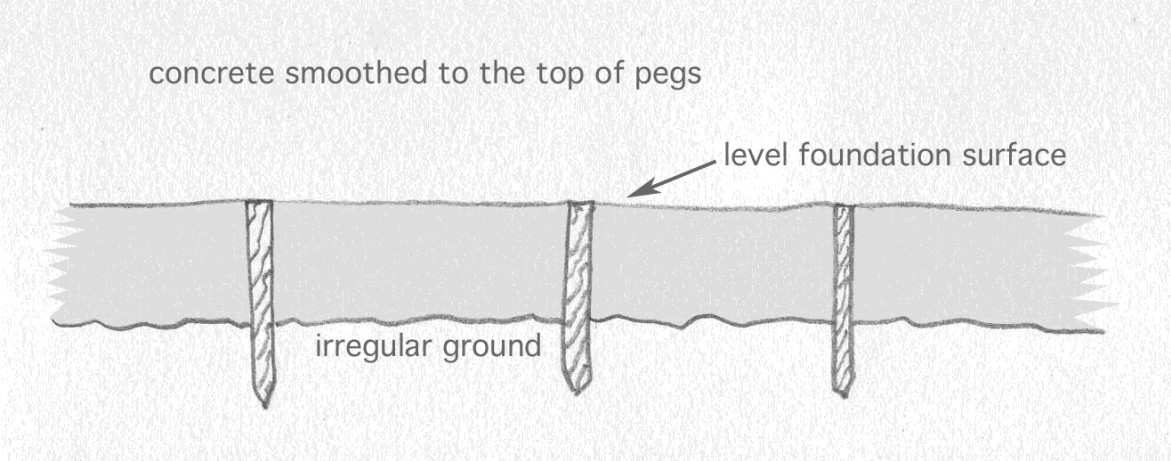
The water level at the end of the pipe corresponds to the water level in the bottle.

A hole has been made in the base of the upturned bottle to allow in air.

Even though this pipe is only 6mm in diameter and 5m in length, we can see the water level at the end of the pipe is the same as that in the bottle.


hole to equalise air pressure
water level
peg hammered down until at the pipe water level
measured to foundation thickness
reference peg

The bunyip will be used here to guide the foundation thickness.



The pegs will be hammered in along the foundation trench ready for the concrete.

A peg is hammered into the trench until it stands 225mm (9inches) tall. This is the trench reference peg, which shows us the finished thickness of the foundation. The bunyip is held so its water level is at the top of the peg.

The bottle is jammed in position so the water level is the same height as the reference peg,

Other pegs can be hammered in until the tops of the pegs are level with the water level in the free end of the bunyip's pipe.

Twelve pegs have been hammered in, a metre apart, around the trench. The tops of these pegs will be the guide for the finished foundation level.

Now, with the aid of a "6 inch" (150mm) auger I am turning my attention to helping the foundation grip the subsoil. The subsoil has some potentially slippy clay-rich patches so I am putting in 150mm wide holes, 300mm (1ft) deep, at metre intervals to help the foundation key into the ground more effectively. (Although, I don't think these holes were essential).

The foundation trench ready for concrete.

Concreting the Foundation

The cement mixer is set up close by to minimise the distance the mixed concrete needs to be moved.

The concrete is standard foundation mix:

cement : sand : coarse aggregate = 1 : 2.5 : 3.5 by volume

An old door is propped with garden forks guides the concrete into the trench.

A direct method of filling the foundation trench.

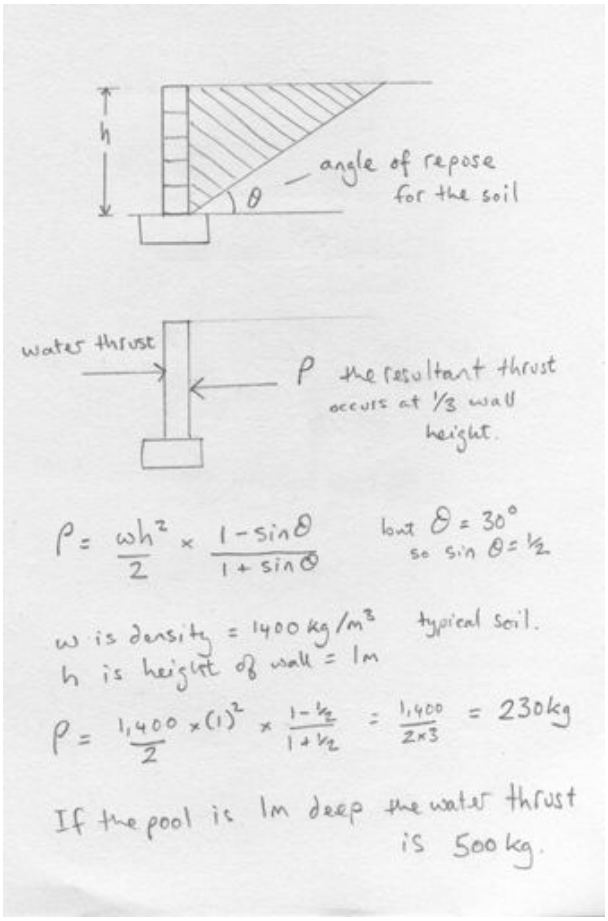
One of the foundation guide pegs in the trench is just about to be covered.

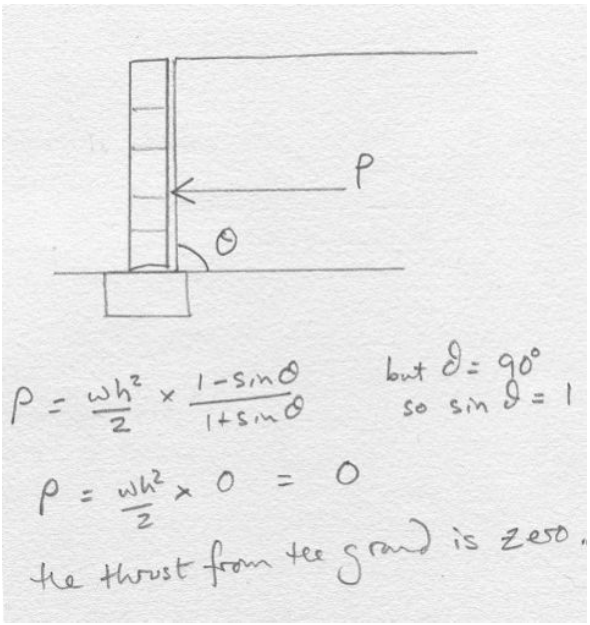
Smoothing the concrete down to the top of the peg makes the surface of the foundation the right level. The foundation will also have the correct thickness, 225mm (9in)

Leveling the concrete with a “float” trowel so the tops of all the pegs are just showing. The whole foundation surface with then be level.

The foundation for the concrete block wall is finished

Building the wall


h
angle of repose for the soil
θ
water thrust
P
the resultant thrust occurs at 1/3 wall height.
P = wh²/2 × (1 − sinθ)/(1 + sinθ)
but θ = 30° so sin θ = ½
w is density = 1400 kg/m³ typical soil.
h is height of wall = 1m
P = 1,400/2 × (1)² × (1 − ½)/(1 + ½) = 1,400/2×3 = 230kg
If the pool is 1m deep the water thrust is 500 kg.



Before any water is in the pool, the 1m high wall can be considered as a retaining wall. The retained soil is the "wedge " of soil held back on top of the normal reposing angle of the soil (i.e. the angle the soil would naturally form a heap at). For most soils it is taken to be 30° and quite conveniently, sin30° = ½

If the soil is 1,400 kg/m3 then the thrust from the retained soil is 230kg

For this situation, it is best to make the wall width ¼ of the wall height. = 250mm (10in)

And, the foundation will have to be twice the wall width, so foundation width = 500mm (20in)

For our situation, as the subsoil is quite happy forming a vertical face, the angle of repose = 90°

And sin90°=1 which leads to the thrust from the soil being zero. The wall is not having to hold back any soil and is merely providing a flat surface for the liner, so a 100mm thick wall is fine.

When the pool is filled with water to 1m then the water thrust against the wall will be 500kg so we need to make sure the wall is solid filled behind so that the outward pressure is transmitted to the subsoil and not putting the wall under stress. As the pool fills up to 2m depth then the outward thrust increases further.

A block is siding down a deal (scaffolding plank) propped in the corner.

Rectangular concrete block.

Heavy, solid concrete block used for general building work.

450x225x100mm (18x9x4in)

The concrete blocks are stacked ready for the wall building. The wall will need around 140 blocks to complete.

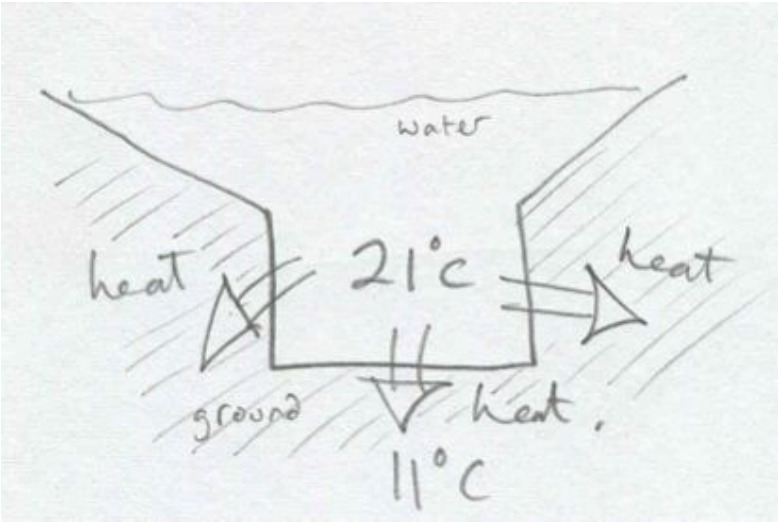
The first row of blocks has been mortared onto the foundation.

The builder's "square" (the big metal triangle) has been used to make sure the corner is a right angle. 50mm thick insulation boards are being placed behind the wall. These are re-used agricultural insulation boards I picked up from a reclamation yard.

Insulating the Wall

The ground temperature at this depth (2m) is around 11 degrees centigrade all year round. During the summer the temperature of the water in the pond will be 10 or more degrees above that. Heat will be lost into the walls, which for a smaller pond is quite significant. In the UK, summer weather is very changeable and for outdoor swimming the water never gets too warm. So, for our climate, insulating the pool were possible, seems sensible. (For warmer climates omit the insulation).

Although there are many insulation materials, only rigid foam boards are suitable for our application. But they don't need to be anything special. I picked these up from a reclamation yard. They had come from a demolished turkey shed.



Heat loss through the walls and floor of the pool.

Due to thermal inertia, heat loss into the ground is less significant with larger pools and insulating the pool becomes less cost effective.

When beginning a row, the corner block is laid first. The guide string (bricklayer's line) can then rest on the top outside edge of the block to serve as a guide for the rest of the row.

Laying some mortar for a block. The blocks are laid in "stretcher" bond, (staggered so the vertical joints don't line up), so a half size block needs to be cut for the end of each row.

Freshly buttered. The thickness of the mortar between each block should end up being around 10-12mm (1/2in).

The mix for the mortar should be;

cement : lime : smooth sand = 1 : 0.5 : 4.5 by volume.

The row is now three blocks high and the bottom layer of insulation board is fitted behind (almost invisible from this angle) along the wall on the left side.

Cutting a block. Usually one or two blocks per row will have to be cut to size. We used an angle grinder fitted with a diamond stone cutting blade. Alternatively, you can just use a club hammer and a bolster chisel. Measure and mark a line showing where the block should be cut. Lay the block on a bed of sand and use the hammer to tap the chisel along guide mark until you have made a reasonable indent. Tap harder all along the line. Then use stronger and stronger blows until the block gives up and breaks perfectly along your line.

Cutting a Heavy Concrete Block

We need, gloves, eye protection goggles, a lump hammer, a bolster chisel and a bag of sand.

Mark a line along the where the break should be made.

Use the hammer and chisel to score along the line a few times. Then go over it again a few more times, making it slightly deeper at each pass.

Just when you think “I’m never going to break this solid concrete block with this hammer and chisel” it cracks.

Admire your masonry work as if you never doubted your brilliance.

As the wall grows, more insulation panels are fitted behind. The wall is now the full height of 5 blocks high and complete with insulation.

Digging the Outer Area of the Pond

Defining the outer perimeter (8x6m rectangle) with a mattock. This micro-trench makes a much cleaner edge than the digger bucket can produce.

The bucket can now break up and remove the topsoil. Then we can dig the subsoil to create a slope from the top of the wall to the pond edge.

Using a mattock and rake to profile and smooth the slope.

The bunyip is set on a stake 2m above the base of the pool to show the future pond water level.

Building a Bank for a Sloping Sit

As the site slopes, the south side (the right hand side) will have to be built up. I am using these reclaimed insulation panels to help me build the embankment but they are not being used for their insulation qualities, just for their rigidity and cheapness. Any boards will do.

The panels are temporally propped with concrete blocks and sand.

Sub-soil is heaped either side of the insulation panels to form the embankment. Here I am banking up the outside of the pond.

Banking up subsoil on the inside (south side) of the pond to the same level as on the outside until the pressure either side of the panels is equal and the embankment is stable. The concrete blocks can then be removed. At least 200mm (8in) of the board should be left protruding as this will need to be trimmed to the right level later.

Sculpting the Subsoil

On one (the north) side of the swimming zone I am shaping the clay subsoil with a plasterer's float. I am making a 300mm (1ft) "step up" to reduce the slope of the beach zone and so reduce the amount of sub-soil I will need to remove.

The “step up” nearly complete on the right. The insulation is still projecting from behind the wall.

Trimming the insulation flush with the wall. I’m using a knife from the kitchen.

Removing the trimmed off 50mm insulation board.

Tamping to compress the soil. This part of the subsoil wall collapsed and needed re-filling with subsoil so it needs a lot of tamping to stabilise the ground. I will make use of this depression later and place the filter here.

Taking off lumps and raking out stones to make a smooth surface. A sharp edge may cause a localised stress to the liner and result in a tear.

Poking with a stick I found a void behind the wall. I am trickling in wet clay slurry to fill it up.

When the pool is filled, the pool water will exert pressure against the wall.

The space behind the wall needs to be filled with subsoil or sand and firmly packed to withstand the force.

More tamping to further compress the soil behind the wall.

The barefoot tamper, well nearly. Steel toecap boots should be worn for this job.

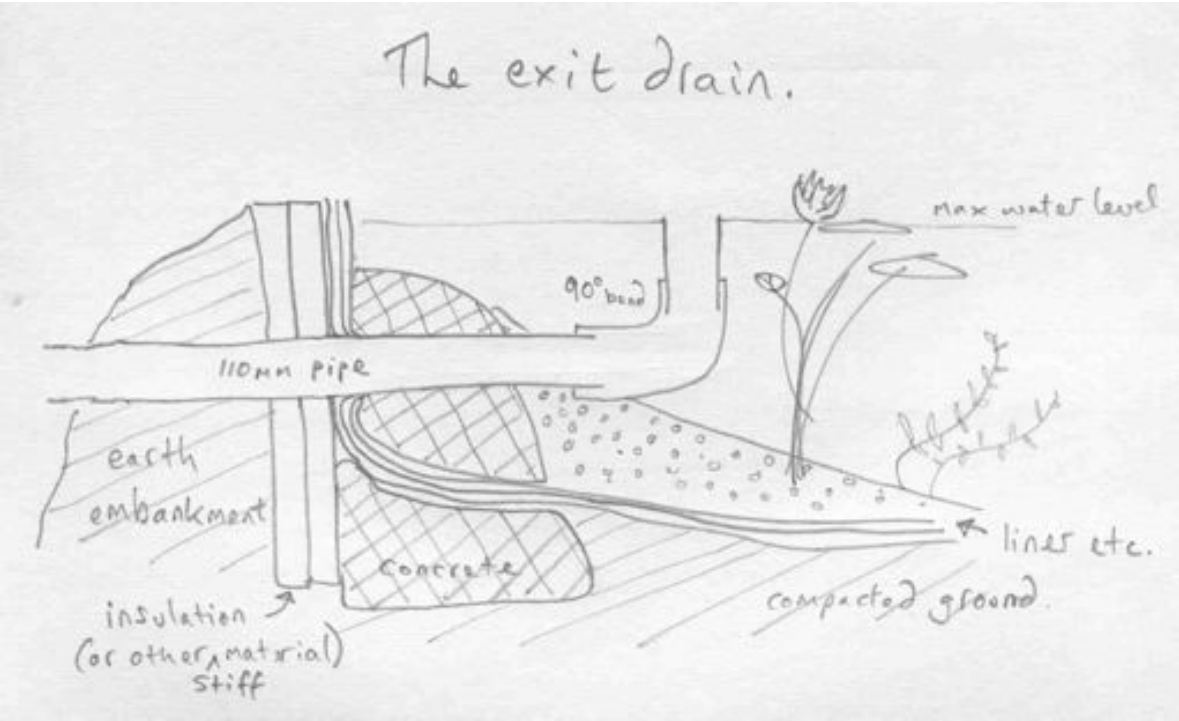
The Exit Drain (Overflow Drain)

This is the exit drain in the finished pool. It is hiding in the planted zone so is hardly visible.

Here we can see how the top of the exit drain determines the maximum water level of the pool.

If the water level rises, it pours into the pipe and out of the pool.

A 110mm drainage pipe with a right angle bend controls the maximum pond level. The pipe through the bank has a gentle slope (2%), to the outside, depositing excess water away from the pond. The exit drain punctures through the liner with a watertight seal and is set in a concrete haunch, which rests on a concrete pad made before the liner is put down.



Digging a hole for a concrete pad for the exit drain.

Some concrete has been dropped in the hole. Another thickness of insulation board is being jammed in, just to give the backing a bit more strength.

Smoothing the concrete pad. (Notice the insulation board placed all around the perimeter of the pond. Here the board provides a vertical support for the liner edge – essential to stop surface ground water running in from the surroundings. See later for alternative pool edges.)

The concrete pad is about 200mm (8 inches) thick. When it has dried the rough edges are scrapped off. Then a couple of inches of smooth sand are laid on top.

Using the Bunyip (to show the pool water level)

The bunyip has been jammed against a wooden peg to show the maximum water level in the pool. We are marking all round the pool to show us where the water level will be.

The water level in the pipe indicates the maximum water level for this pool.

Cutting down the excess insulation board to around 100mm above the maximum water level mark.

Here, the bunyip bottle is tied to a stake and I am re-checking where the maximum water level will reach around the pond.

Sieved sand is brushed over the bottom of the swimming zone.

50mm thick reclaimed insulation slabs are laid on the sand floor.

More sand is brushed into the cracks and corners.

The whole outer pool area could be covered in 4 inches of smooth sand to further protect the liner from stones. But for this site, the ground is smooth enough not to need it.

Calculating the area of lining materials required

Liner width = 1.2 x pool width + (2 x pool depth)

Liner length= 1.2 x pool length + (2 x pool depth)

The pool is 6m wide and 2m deep. The pool will actually be capable of holding slightly more depth (2.1m) to cope with a sudden downpour of rain.

The width of liner needed is the pool width, with a 20% margin for adjustments, (can be reduced to 10% in most cases), plus twice the depth (the liner goes down to the bottom and then back up again).

So, the liner width needed is:

6 x 1.2 + 2 x 2.1=11.4m

The same calculation for the 8m length of the pool gives us:

8 x 1.2 + 2 x 2.1=13.8m

Minimum liner size needed:

Checking the width for the liner with a tape measure.

The underliner fabric is cut with a craft knife.

The Underliner

The underliner is a non-woven geotextile, laid on the ground to protect the liner from sharp stones and edges. This particular product is called Polyfelt TS60, 260 grams per metre square. It is a non-woven synthetic material. The underliner comes on a 2m wide roll. The same fabric is used for both the underliner and the overliner. So, in total we need around double the area of geotextile compared to the liner, around 300m2 of geotextile. (We don't use an overliner in the swimming zone, but we use extra along the edges and corners so it works out about double the liner area.)

The geo-textile is temporarily held down with a couple of lengths of timber in the deep area and stones around the edge.

The sheets of geo-textile are joined together with just a quick wave of the flame from a gas blowtorch. Some of the surface fibres of the geo-textile melt and if the two surfaces are padded together quickly it forms a good bond. This takes a bit of practice. Heat the textile for slightly too long and you'll burn a hole. Heat for not long enough and they won't stick together.

A quick wave of the flame and the material is dabbed down. The heat is momentary, but it is best to wear gloves.

Handy tip: If the geo textile is damp, the blowtorch won't get it hot enough to melt the fibres (the latent heat of vaporisation sees to that.). You'll be blasting away and the geo-textile will steam and maybe singe but never stick.

If the textile is dry, then a swipe from the flame will briefly melt enough fibres to stick the surfaces as they are quickly slapped together.

The sheets are all stuck together forming a protective layer over all the surfaces of the pool. This will ensure there are no sharp edges that might stress the liner.

I have put a double layer along the edge of the wall and in the corner.

The liner

Traditionally, clay has been the material to line pools and canals with but it requires a huge amount of physical effort; teams of navvies to lay and herds of cows to puddle. Hence, it is not such an attractive option. Also, if there isn't a local supply of suitable clay it will have to be processed and transported, so its sustainable credentials start slipping. Also, swimmers can disturb the clay sediments so the water clarity may diminish when the pool is being well used.

For us, plastic is a more practical liner. However, synthetic liner is the product of the petro-chemical industry and hence not an environmentally sound material. At least we are making a pond that will benefit wildlife so it is probably one of the better uses for oil.

There are many different plastic pond-lining materials, all with differing properties and multitudes of confusing claims from each manufacturer. Synthetic pond lining materials include: PVC (polyvinylchloride), PEHD (polyethylene high density), EPDM (Ethylene Propylene Diene Mixture), and Butyl. For this project, the most versatile and long lasting materials are Butyl or EPDM. Between these two, there seems to be very little difference in performance so I opted for EPDM because it is cheaper.

The liner is a synthetic EPDM rubber, called Pondguard manufactured by Firestone.

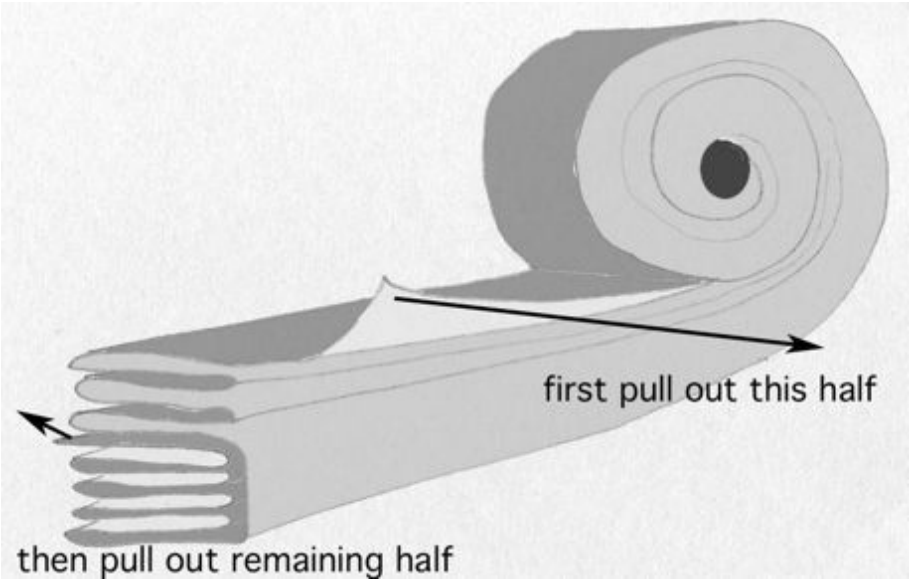
The 1 mm thick liner is just over 15 metres by 12 metres (slightly bigger than I need but this is the nearest “off-the-self” size). It weighs 232 kg.

The liner has been rolled in the factory lengthways so the roll needs to be positioned at one end of the pond. As the liner is very heavy, if you start rolling it out from the wrong place, it will take a lot of effort to rotate it afterwards. It is hard enough trying to do it the proper way.

The friction of the liner on the floor is too great to pull the liner out continuously. We are using a fence post to pull folds along in a sort of peristaltic movement.

The liner is rolled out lengthways

The liner is shuffled over to the middle. The liner has been folded in the factory to be unfurled from the centre.



The liner is folded and rolled to make it easier to unfurl on site.

The folds are pulled out to one side at a time.

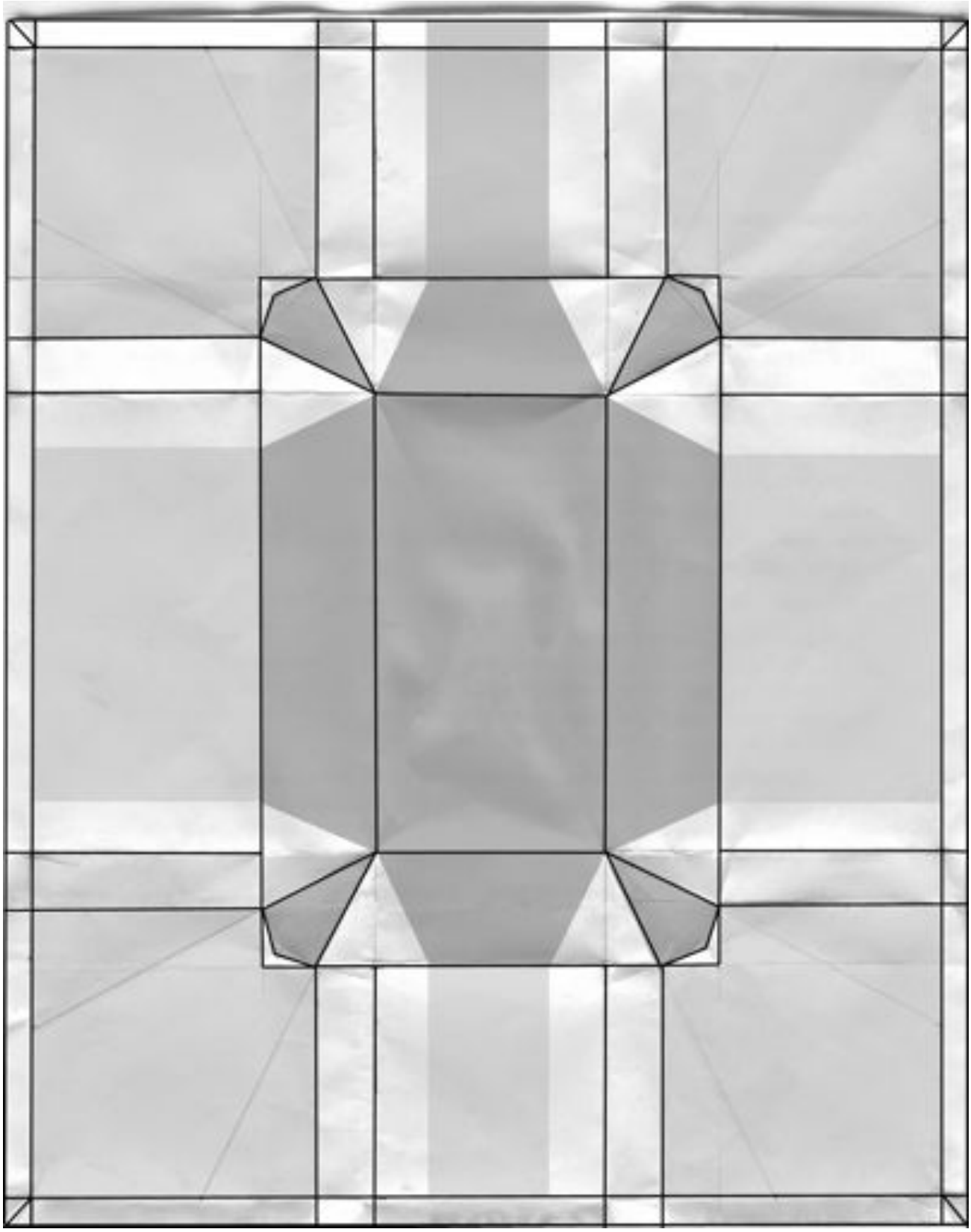
One half of the liner is pulled out.

The liner has been folded in such a way that when one side has been pulled out completely, the other lengthwise edge of the pond liner is revealed.

We can now pull out the liner to the other side.

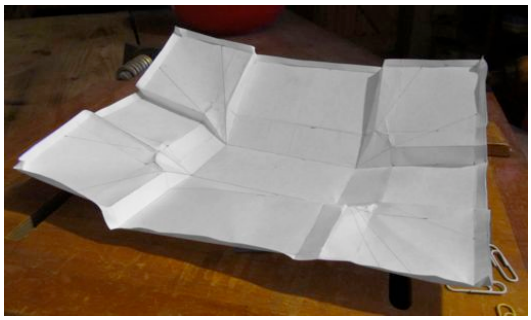
The liner is pulled out to cover the whole pond.

Start with the floor of the pond, getting it aligned square and central. Then pull up the excess up and over the wall. Once the floor is smooth then gather the remaining excess along the walls and into the corners.



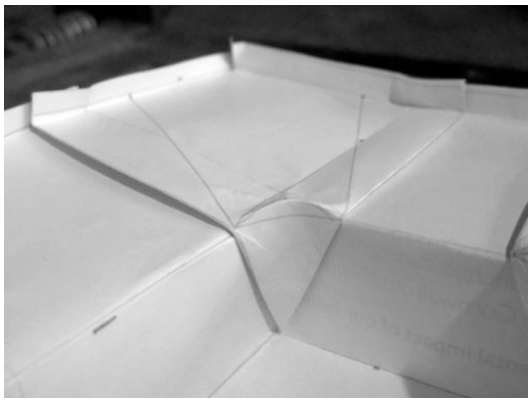
A flat-pack organic pool. Make folds along the black lines and with a lot of finger dexterity you end up with a 3 D model of the pool.

Paper Folding a Pool



I found it really helpful to try folding a piece of paper into the shape of the pool. In the process I discovered the corners needed some odd little triangular folds that projected upwards.

Try folding the shape yourself. Make a copy of the previous page, (I know you shouldn't copy any page from this book because of copyright issues, but you're OK just for that one. Tell the police I said it was OK. Give them a copy of this page to prove it… on second thoughts that will only cause more trouble).



The black lines indicate a fold. The darker shaded area is the swimming zone and the lighter shaded is the beach and planted zones.

The corner "kite shaped" mitre folds. We can see how the top of the fold projects above the wall height.

Upside-down we can see the deep section has neat corners.

Paper clips are a great help during the intermediate steps of creating this origami model.

If you find this tricky, rest assured it is easier doing it for real with the liner.

Making Folds in the Liner

The reason I fold the liner, is not to demonstrate the extreme sport of "Pool-liner-Origami"' but to eliminate the need to cut the liner. Cutting the liner to the size and shape of the pool requires making joins, which are tricky to make in the field and are prone to failure. It is best to avoid them. The method I've come up with creates flat and smooth walls, which will make the pool easier to clean and also free from unsightly creases.

Working on top of the liner requires due respect. Take off your boots.

I am pushing the liner into the top edge of the corner and pulling the excess back over to making folds roughly 550mm wide – this corresponds to half the height of the 1.1m wall.

A 68mm diameter rainwater pipe will help me make smooth mitre folds in the corners.

The bucket is being used as a moveable anchor for the rope. It is placed near an outer corner of the liner.

The pipe is held by the rope at the top, and sandbags at the bottom. This makes the folding easier. The liner has been smoothed flat along the walls and into the corners, behind the triangle of excess liner.

The fold evoles into a triangle. A half “kite shape”.

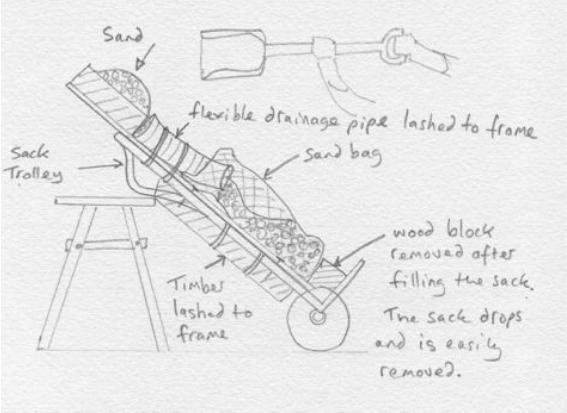
A sandbag temporarily cushions and jams the foot of the pipe. We can see rainwater has started to collect in the pond.

The “kite” shaped mitre fold projects ~150mm above the wall. The pipe and more sandbags help keep it properly formed.

The pipe has been removed. The sandbags are now sufficient to hold the mitre folds. These folds will flatten against the wall when the pool fills with water and hardly be noticeable. If your sensibilities require further amelioration then they can be hidden behind steps or ladders leading into the swimming zone.

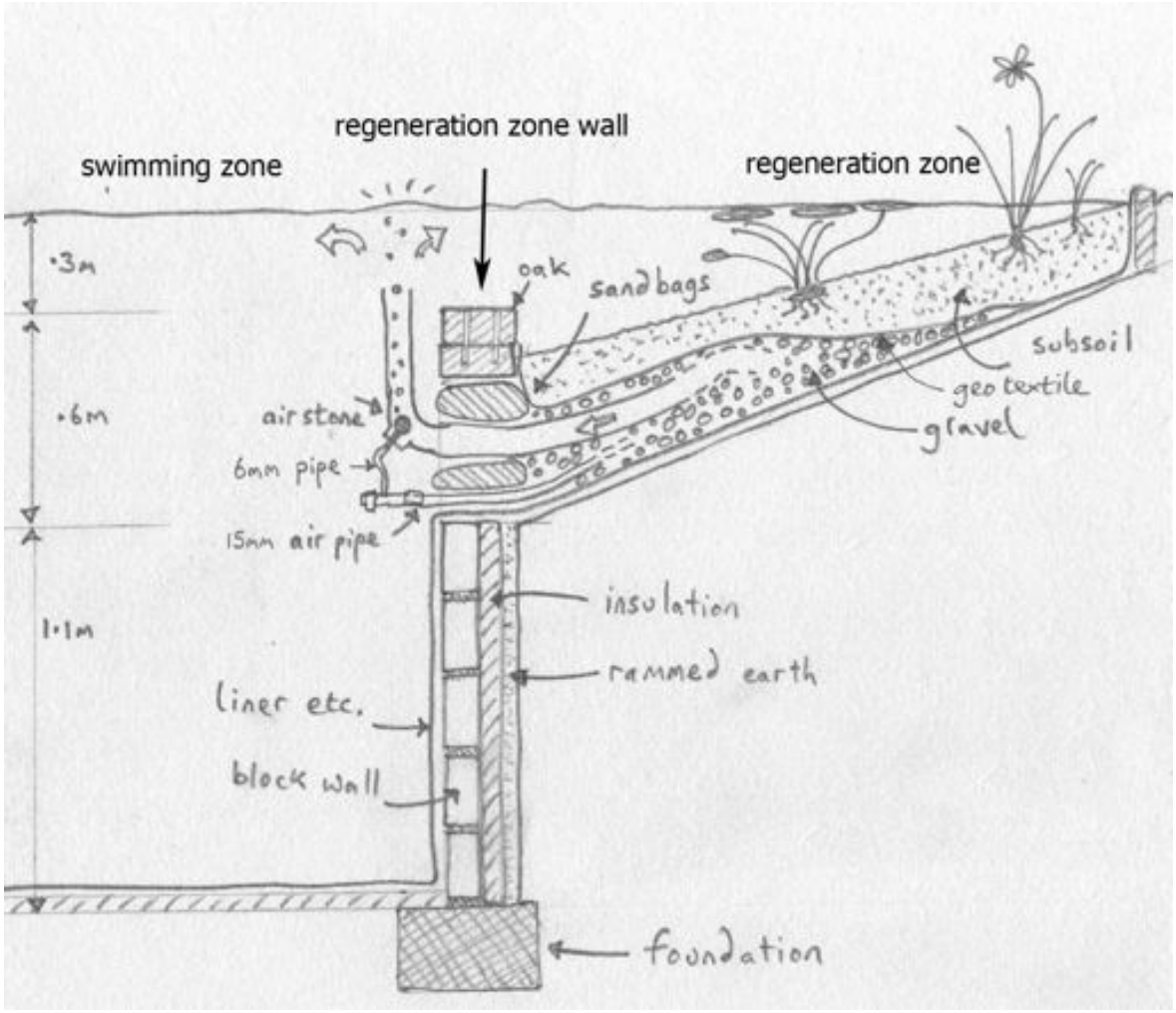
The Sandbag Machine

An old sack trolley is re-born as a sandbag filling aid. A couple of lengths of timber have been jammed and lashed onto the tubular metal structure of the trolley and some pieces of plywood have been nailed on to them. At the top I've made a "V" shaped funnel from more scrap timber. The plastic drainage pipe is tied to the timber allowing it to spring up enough to grip the mouth of the hessian sack. This holds the bag while it is being filled.


Sand
flexible drainage pipe lashed to frame
Sack Trolley
Sand bag
wood block removed after filling the sack.
Timber lashed to frame
The sack drops and is easily removed.

Once filled, the sack is released with a gentle tug away at the bottom of the tube. The sack duly slithers off the tube and slumps down a few inches to the base of the trolley. The sandbag's strings can then be tied to seal the mouth of the bag.

The Regeneration Zone Wall



There are many ways to build the regeneration zone wall and many possible materials. Bricks, concrete blocks, timber and plastic have all been used in Natural Swimming Pools. I chose to use sandbags filled with a dry sand and cement mixture. Sandbags are soft and malleable and can be laid almost anywhere without the use of mortar. Loose fragments of hardened mortar that have accidently dropped into the pool could be hazardous to the liner. Also, the sandbags can be filled with any rough sharp sand. The pool excavation had produced a heap so I could re-use that without clocking up too much embodied energy. I used hessian sandbags that will decay over a few years, leaving behind a soft organic concrete shape but in the meantime they do look a bit messy and introduce some nutrients as they break down. So they are not so perfect, but my pools seem to cope. Underwater, synthetic material sandbags are also fine. They don't rot and the water filters out almost all of the ultra-violet light that damages plastic. However if they are exposed to direct sunlight over a period of just a few weeks they can quickly degrade to be no stronger than tissue paper.

The Sandbag Wall and the Overliner

The first piece of overliner - Polyfelt geo-textile, is folded double over the thickness of the wall. This gives the liner more cushioning and creates a nice neat fabric edge. The overliner is temporarily held down with half-filled sandbags.

More pieces are added and overlap with each other by roughly 100mm. The first row of the sandbag wall is being laid. The sandbags are filled with a dry mix of 8 parts sharp sand to 1 part cement. When the sandbags eventually rot they will leave behind their soft organic shape. Sandbags have the advantage of moulding to the surface they rest on so they can be sacked directly on the wall, trapping the layers of liner and underliner. If the wall is to be made of bricks or blocks then a mortar bed would need to be laid on the double thick geo-textile.

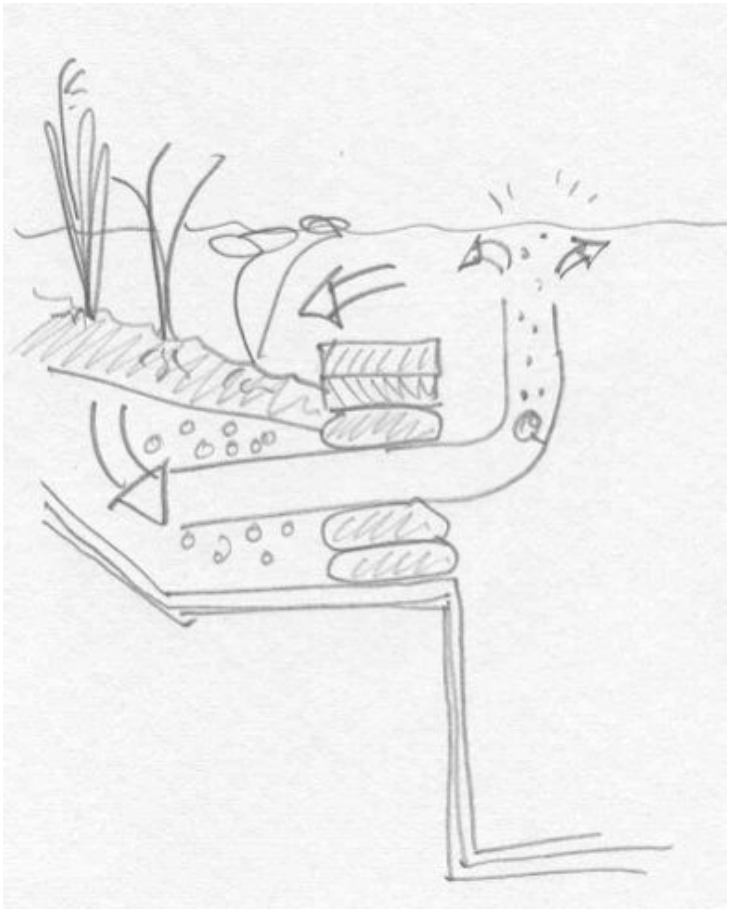
The pieces are stuck together with the blowtorch. Applying just the same technique as joining the under-liner.

The whole of the outer area of the pond is covered with over-liner. This protects the liner from the gravel and substrate that will be layered on top. The swimming zone is not covered because the liner makes a smooth surface to aid cleaning the pool.

Fitting the Bubble Pump pipe into the sandbag wall

A short length (60cm, 24in) of 110mm (4.5 inch) drainage pipe and a 90 degree bend are parts for the bubble lift pump. This will provide the water circulation for the regeneration zone. It is temporarily held in position with some sandbags.

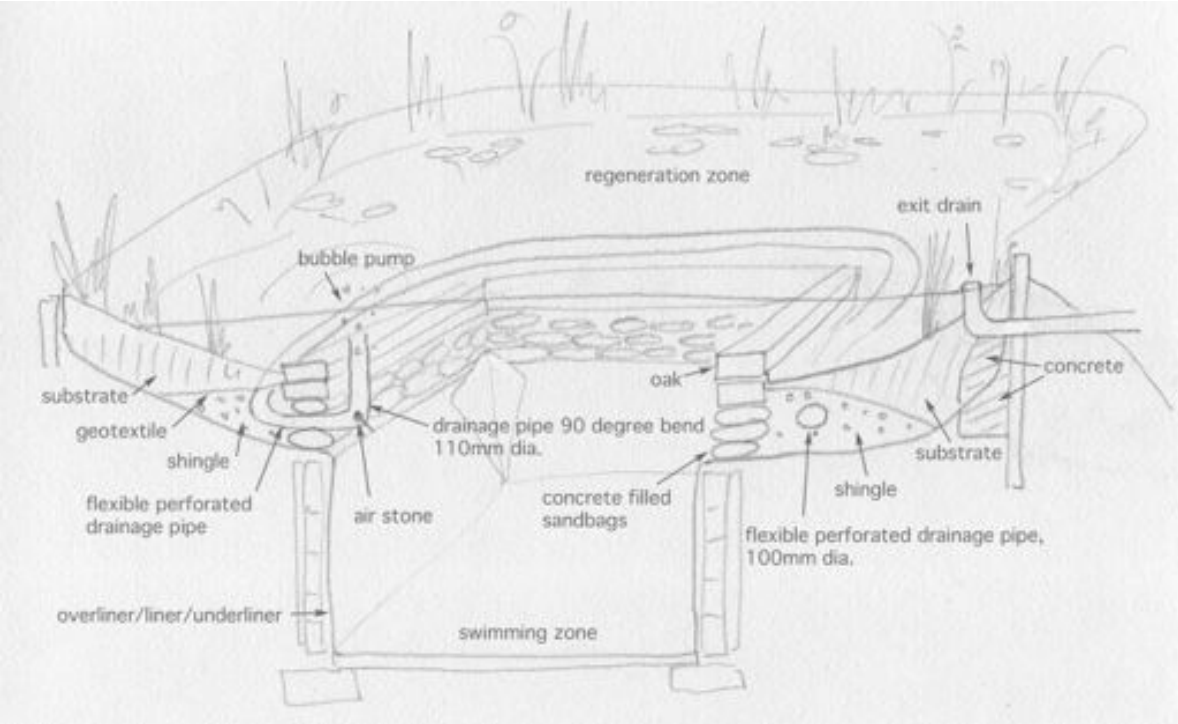
The wall is now built to incorporate the bubble lift pump. In various places in the sandbag wall I have put 15mm grey plastic plumbing pipe. They will supply the air to the bubble lift pumps. Some are spare and available just in case I need them at some point. The brown sandy water in the bottom of the pool is rainwater collecting as we build. The race is on!



110mm diameter bubble pipe for the bubble lift (air-lift) pump and the 15mm pipe for the air supply.

The pump is inherently simple and reliable. It is also capable of moving large quantities of water with very little power. The column of bubbles in the pipe creates a low-pressure zone drawing water from under the planted area.

Completing the Exit Drain



The exit drain is a 110mm dia. drainage pipe with a right angle bend to control the maximum pond level. The exit drain, set in a concrete haunch, punctures through the liner with a watertight seal and deposits the excess water away from the pond.

Making an upper concrete pad for the exit drain. This is on top of the overliner/liner/underliner and the lower concrete pad. I have made a temporary basin from sandbags and a piece of geo-textile to hold a dry mix of general purpose concrete (cement : sand : aggregate = 1 : 2 : 3 by volume).

The concrete for the pad has hardened. I have pulled back the liner to cut a 110mm hole to allow a drainage pipe through.

I am using a hacksaw blade to cut the insulation.

Pushing a 1m length of 110mm drainage pipe through from the outside.

Back on the inside. I have pushed a wooden board under the liner so I have a firm surface to cut the liner on.

Draw round a spare piece of 110mm pipe to mark a circle where the hole needs to be. With a craft knife, cut from 5mm inside the circumference to the centre. Rotate approximately 30 degrees and do another until you end up with covering the circle with about twelve cuts.

Push the pipe through. It should be a tight fit. The liner material will stretch around the pipe forming a good seal.

With waterproof duct tape, fix the liner to the pipe.

Cut the overliner to allow the pipe to go through, then the overliner is pulled back into place.

I have put an extra piece of geotextile over the pipe just to cover the cut I made in the overliner. The pipe is propped up into the right position with a gentle slope to the outside of the pool. More dry mix cement can now be built up around it.

Using a tamper to push it down. The layers of fabric can make it initially quite springy.

The concrete haunching has now hardened so the sandbags and bits of insulation can be removed.

Capping the Wall

I am capping the wall with oak sleepers just because I have them to hand and like the look of them. The wall can be capped with stone, bricks or blocks. Equally, I could have used more concrete filled sandbags as the capping.

Making a lap joint in oak sleepers.

Laying the oak sleepers to cap the concrete filled sandbags.

Fixing the oak sleeper to each other with 175mm lengths of 12mm thick stainless steel threaded rod. As you can see, I have started bringing in a heap of gravel ready for a later stage.

The oak is propped with bits of wood here and there and then loose filled bags containing the dry concrete mixture are pushed into the voids under the oak sleepers.

The finished swimming zone/planted zone dividing wall.

Putting in the Planted Zone Circulation pipes

We need around 20 metres of flexible drainage pipe for this pool.

100mm diameter flexible drainage pipe I pulled out of a skip.

100mm flexible drainage pipe fed into the 110mm bubble pipe. I sealed them together with waterproof duct tape.

This white bit of pipe just jammed into the black pipe.

I need to perforate these 100mm flexible drainage pipes to allow water to circulate freely from the gravel. You can purchase them in perforated form, so then there is no need to manually drill holes everywhere.

The shingle is laid over the 100mm flexible perforated drainage pipes to a depth of about 300mm.

I have left haunches in the oak so I can weight the frame down with sandbags. This will fix the frame in position and stop it floating.

Here's a token half hearted, half filled sandbag just thrown on for the photograph.

The shingle bed containing the perforated drainage pipes is covered with a layer of geotextile

I have just scattered gravel over the geotextile to keep in from blowing away. The first shovel full of subsoil is about to be thrown on top of the geotextile. The subsoil will be my plant substrate. Subsoil however, is a contentious substrate.

The Substrate

The substrate is the medium in which the plants grow. It should not provide many nutrients so the plants have to take them from the water. The plants then directly compete with the algae for the nutrients and suppress the algae's growth.

The most widely used substrate for Natural Swimming Pools is washed 20 mm marine shingle and sharp sand, mixed in equal quantities. There are environmental issues with extracting marine shingle so I have thought it best to avoid using it. Marine shingle is also expensive and, unless you live near a dredger, not local.

Instead, I use the subsoil dug from the pond. Not the topsoil - that has too many nutrients. In my opinion, the local subsoil should provide the best medium for local flora to grow in. After all, a pond found in the countryside has subsoil for the plant substrate, so they should be perfectly adapted for that. However, there are some important caveats. The subsoil may have been polluted with agricultural fertilizers, which could prove a tasty recipe for algae. Also, the soil may contain naturally occurring mineral phosphates or other plant fertilizer. If you want to be sure you could get the subsoil tested in a laboratory to see if the levels of contaminants are going to be a problem. The next best option, in environmental terms, is to use locally quarried gravel and sand and give it a good wash before introducing it to the pool.

Using the subsoil as substrate has another big advantage - it is free. And it will save having to otherwise dispose of it somewhere else.

The substrate (sub-soil being used here) for the plants to grow in is being shovelled on top of the geotexile.

More subsoil but now bucket-fulls tipped on.

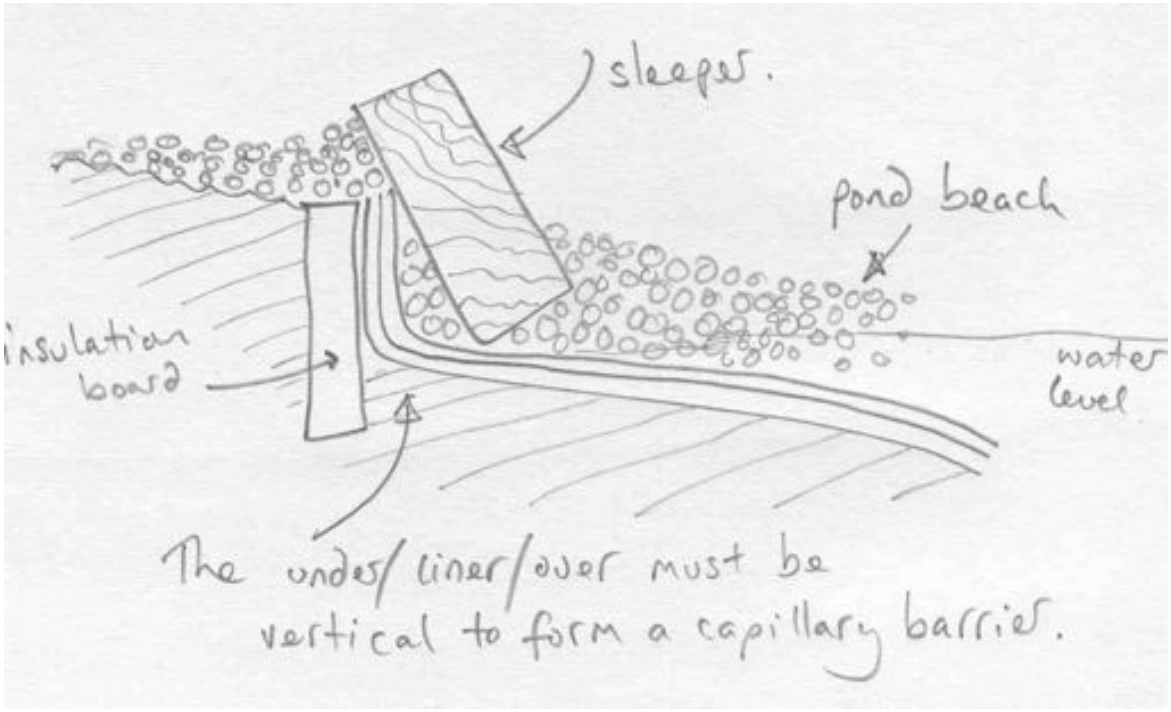
Working on the Pool Edges

A 90 degree bend is fitted to the 110mm diameter exit drain. This will ultimately control the maximum water level in the pond. At the moment it helps to keep soil out of the pipe.

One half of the shallow pond area is going to be a beach. We have had delivered 10 tonnes of 20-30mm shingle from a local quarry. The closest place the lorry could get was the top of the field so it has to be moved from there to the pond. We are shoveling shingle from the trailer. The blue barrel is my pool filter – I'll show you how I made it shortly

.

The site slopes and on this side of the pond there is quite a step up. I'm using some oak sleepers to make a quick and simple edge to hide the under/liner/over.



The oak edge cross section. The under/liner/over need to be in a vertical position to be an effective capillary barrier.

This edge proved not to be sufficient for the amount of traffic around this part of the pool. I re-made this edge a few months later. See the later section: Making a stronger edge.

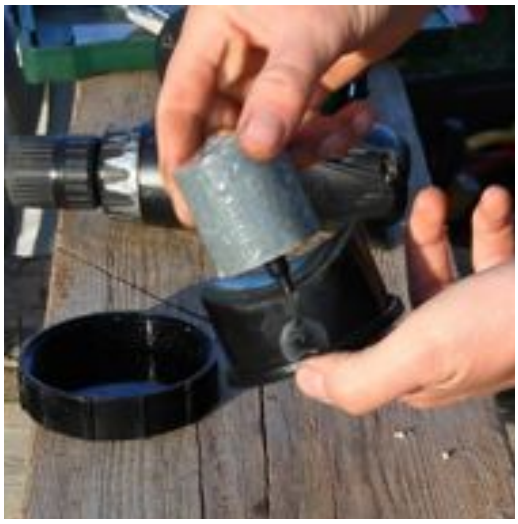
Gravel has been spread around the edge to create a natural looking beach. (I later make this edge more substantial – see the later section, re-making the edge)

Just a final bit of landscaping with the rake.

Plumbing for the Regeneration Zone Bubble Pump

This 110mm 90 degree bend has an inspection cap assembly. The cap screws off and inside there is a plug with a curved face corresponding with the inner surface of the pipe.

A 5.0mm hole is drilled into the curved inner section of the inspection assembly.



The air stone has a tapered inlet nozzle, which is fed through the 5.0mm hole until it jams and fixes firmly to the assembly

The 6mm dia. aquarium air pipe is then pushed directly onto the tapered nozzle sticking through.

A 6mm dia. hole is drilled in the inspection cap to let the aquarium air pipe pass through.

A 5.5mm hole is drilled in a short length of 15mm plastic pipe.

15mm plastic plumbing pipe insert being pushed into the pipe. These keep the pipe rigid for the fitting to be sound.

A 15mm “stop-end” fitting has been push on. The 6mm diameter aquarium air pipe is twisted and eased into the 5.5mm hole to form a firm watertight fit.

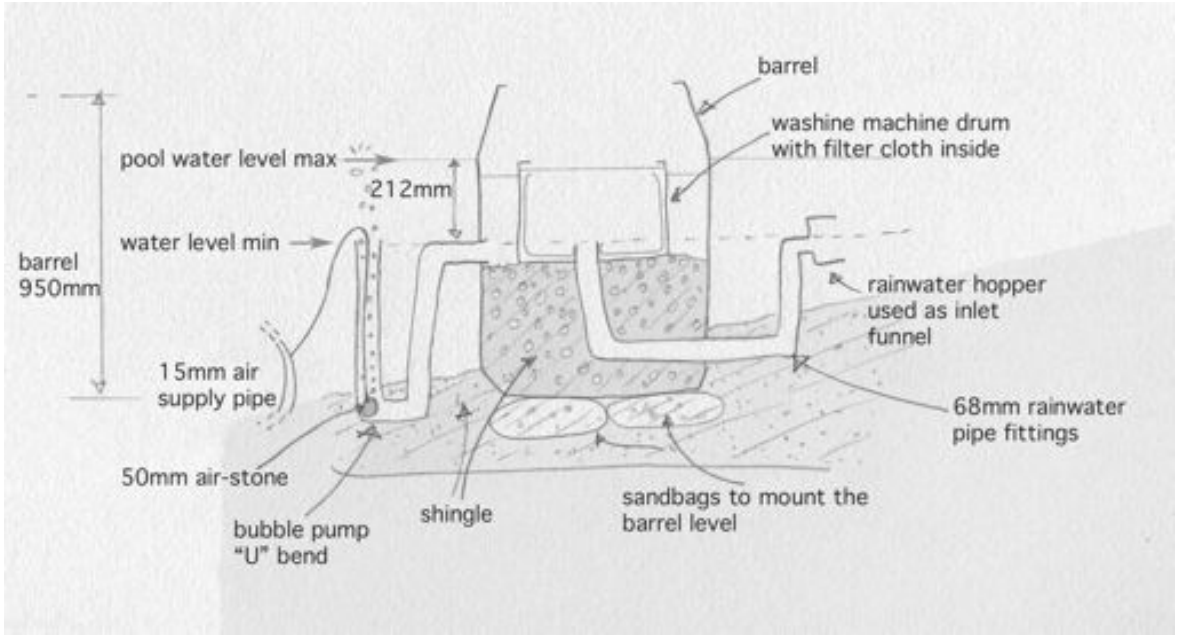
The pipe has been cut down the to about 4 inches (with the pipe cutter) and a straight-coupler fitting (plus insert) fitted to the other end.

Complete assembly.

A simpler alternative is to drill a 5.5mm hole in the end of the "stop-end" fitting. This could then be pushed directly onto the supply pipe.

The 110mm bend inspection assembly is fitted and the straight-coupler pushed onto the 15mm air supply pipe (with a pipe insert). We can see the air stone is held neatly in the centre of the 110mm pipe.

Making a Bubble Pool Filter



How it works:

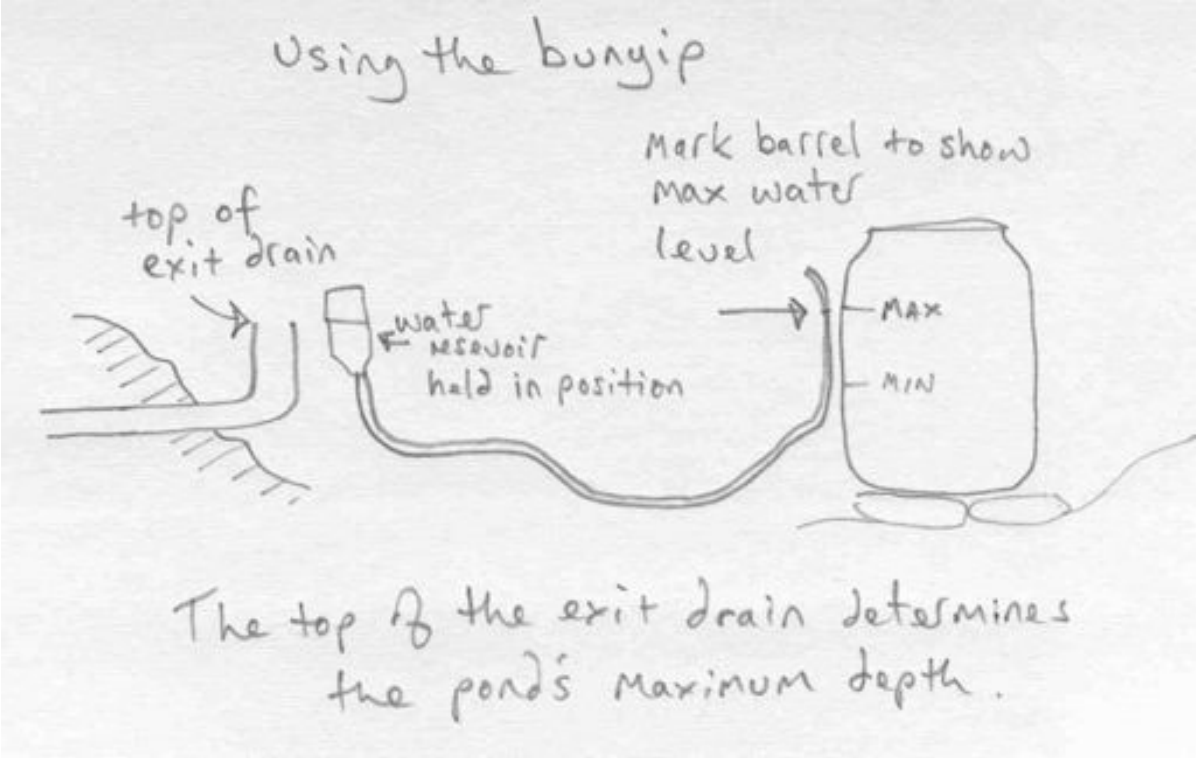
The bubble pump (on the left) draws water upwards out of the pipe and sucks water from inside the barrel. This lowers the water level in the barrel. Water from the pool is at a higher level so it flows through the inlet pipe (on the right) into the washing machine drum inside the barrel. The water flows through the holes in the sides of the washing machine drum, which is lined with fabric. This filters the water and retains the debris and sediments within the drum. When the filter needs to be cleaned the washing machine drum can be lifted out and the cloth rinsed to remove the built up sediments.

Pool Filter Ingredients:

One fruit juice barrel.
One washing machine drum (or a plastic basket).
Around 3m of 68mm dia. rainwater pipe for connecting up.
68mm PVC rainwater pipe fittings:
2 x 112.5 degree offset bends
5 x 92.5 degree bends
Also:
Some gravel.
One piece of filter cloth – geotextile
One lid – wooden or hidden under a jetty.

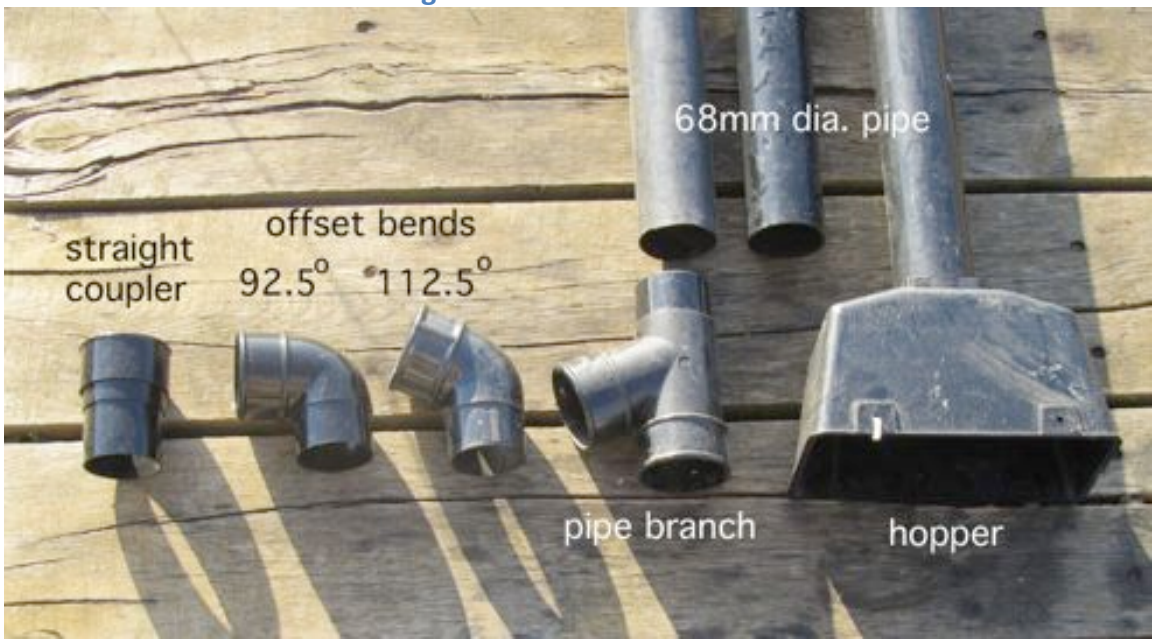
Method:

Place the barrel in position in the pool and using the bunyip with the reference end at the top of the exit drain (the maximum water level in the pond) mark the maximum water level on the barrel.


Using the bunyip
Mark barrel to show max water level
top of exit drain
water reservoir held in position
MAX
MIN
The top of the exit drain determines the pond's maximum depth.

Measure the depth of your washing machine drum (or other basket you want to use). My drum is 280mm deep so I will use this figure.

If we make allowance for the filter's outflow pipe (68mm) then the minimum water level at which the filter will operate is 212mm (280-68) below the maximum level. Mark this on the barrel.



68mm dia. Rainwater fittings I use for the project.

Making a pilot hole in the barrel for the inlet pipe opening.

A 70mm diameter core drill placed ~100mm (4 in) from the base of the barrel.

Drill another hole for the outlet, centred 35 mm (1.5 in) below the minimum water level mark. The top of this hole then should be at the minimum water level. (See the filter drawing)

I have taken a few washing machine drums out of old machines before, but this one I found in a scrap yard, which is a lot easier.

A pilot hole has been made for the 70mm core drill.

Wear ear defenders, it's noisy.

The right angle of 68mm pipe work pushed together inside the barrel. This will be the filter's inlet pipe. The horizontal pipe is around 60cm long. The vertical pipe should be just long enough to come up to the minimum water level marked on the barrel.

Gravel has quite low embodied energy so I try to use it in preference to concrete. And quite pragmatically, I can also easily redo something if it doesn't work out.

Inside the barrel, the gravel is spread around the 68mm pipe. It keeps the pipe vertical and the weight of the gravel secures the barrel in position.

A 90 degree pipe fitting joins the inlet pipe with another length of pipe to stand vertical.

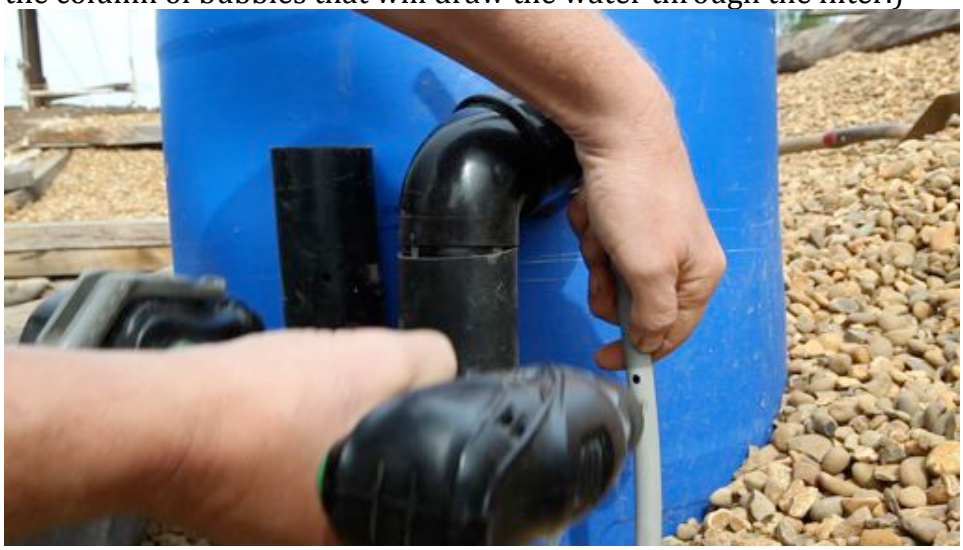
Filling around with more gravel to hold the 68mm pipe vertical.

I have cut down the 68mm pipe and fitted a 112 degree fitting and a hopper. (I later replace this hopper with a skimmer –see the later section “Making a Surface Skimmer for the Filter”).

Making the “U” bend for the bubble lift pump. I’m pushing together two 112 degree offset bends. At the other end there are two 90 degree bends. These fittings are just pushed togther, not glued, so they can easily be manipulated into the correct position. Also, the fittings aren’t messed up with adhesive solvent so they can readily be re-used in the future. (Also, it is best to minimise the pond water’s exposure to potentially polluting solvents.)

The two offset bends can adapt to almost any angle to get into the barrel.

A short piece of 68mm pipe is fitted to complete the “U” bend. (This pipe will contain the column of bubbles that will draw the water through the filter.)



Drilling a 5.5mm hole straight into the 15mm air distribution pipe.

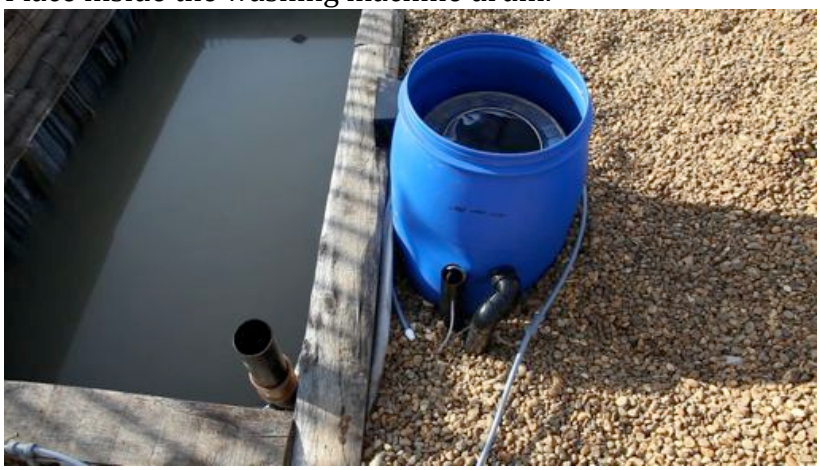
Jam into the 5.5mm hole one end of a 1m length of 6mm aquarium air pipe. A round aquarium air-stone (50mm) is fitted to the other end of the 6mm pipe and just lowered to the bottom of the “U” bend.

The 15mm pipe has been trimmed down and I’m pushing on a 15 mm “T” piece fitting to continue the distribution pipe to other outlets. Remember, these fittings need “inserts” which fit in the ends of the pipe before the fittings are pushed on.

Fitting Fabric in the Filter.

My filter medium is a piece of geo-textile. A 70mm diameter hole has been cut in the centre to line up with the hole in the drum. They will both fit over the 68mm inlet pipe inside the barrel.

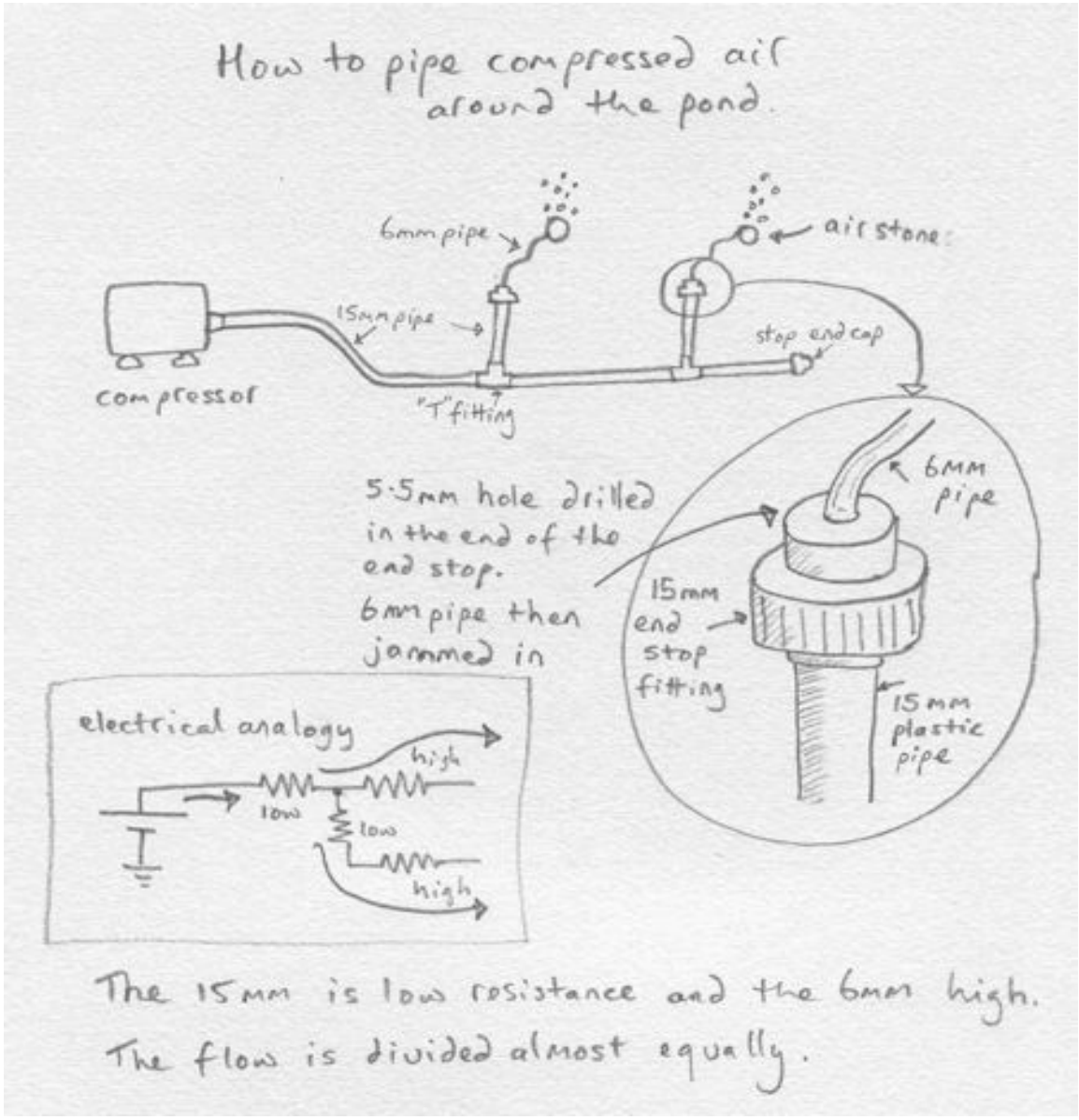
Place inside the washing machine drum.



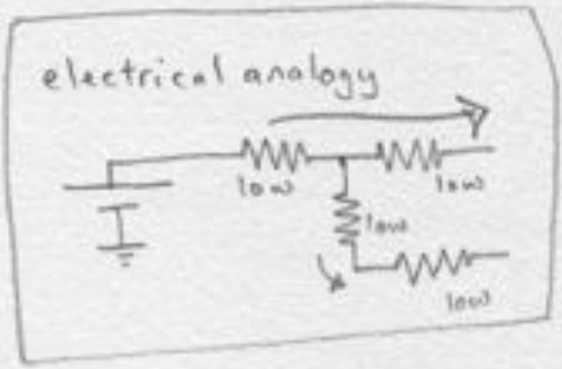
The 70mm hole in the bottom of the washing machine drum fits over the 68mm pipe inside the barrel. The filter is now complete. It just needs air and water.

Connecting up the Compressed air Pipework

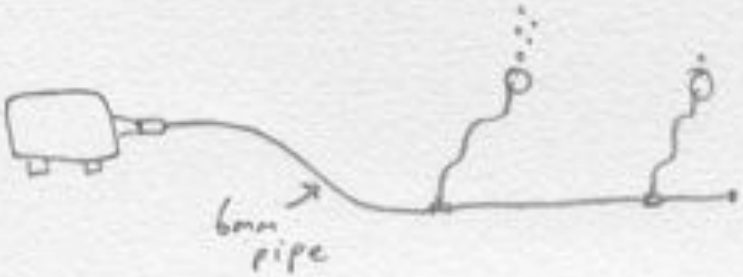
To ensure all the air outlets are fed fairly evenly it is important that each outlet has a short section of 6mm aquarium air pipe into each air-stone. This small diameter pipe has a higher resistance to the airflow than the 15mm (standard domestic plastic plumbing) distribution pipe, so the air divides equally.



Dont use 15mm pipe direct to the airstones.



most of the flow will come out of the first air stone.



Using 6mm pipe for the distribution will offer too much resistance - reduced flow.

The compressor needs to be above water level or it may siphon out water when turned off.

Filling the Pool.

Tap water can contain phosphates – the main limiting plant nutrient, so I don't want to use it. Instead, I am pumping water from all the rainwater butts we have. Rainwater is the best water it is less likely to contain many nutrients.

As the pool fills the water pressure presses the liner flat against the wall. Also we can see some spare 15mm pipe outlets fitted with stop-ends sticking out of the wall.

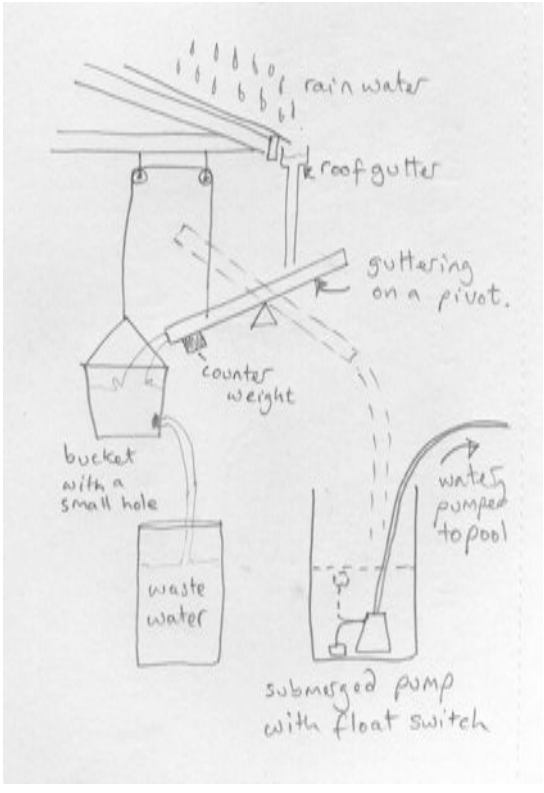
If rainwater is collected from a roof, the “first flush” containing bird dropping and leaf litter should be diverted. There are easy (and fun) ways of doing this involving buckets and pulleys.

This splendid device is made from some guttering pipe on a pivot. When the water first flows it is diverted into the bucket. This fills and after a short while, tips the pivot. The roof water the runs straight on into the pool.

See this on Youtube.com/organicpools

rainwater diverter

In a water butt under the guttering outflow, I have a submersible pump fitted with a float switch. It is coupled to 25mm water pipe that leads to the pool.



Planting

It's natural to think that our new pond is an empty habitat that needs filling up as soon as possible. The reality is, many species of animals and plants will move in with remarkable speed without any help from us. So, doing nothing is a really good option, and if we were creating a purely wildlife habitat then this would be our preferred approach.

But we're probably a bit too excited. We want to start swimming and can't wait for plants to move in when the fancy takes them. So, to speed things along, we indulge ourselves in some aquatic gardening.

If plants are to be introduced, then we should aim to use only native plants found within ten miles of the pool. This helps maintain the distinctiveness and biodiversity of the local wetland species. And as local species will be best suited to the environmental conditions of your pool, they should be more successful than non-local plants at competing with algae for nutrients. And local native plant species will provide the best conditions for a vibrant and interconnected ecosystem.

For a list of local plant species, here in the UK we have The Postcode Plants Database run by the Natural History Museum, www.nhm.ac.uk

I must admit I regret one of the plant choices I made for my pools. I used a non-native, Curly Waterweed or Fishweed (Largarosiphon major) as my oxygenating plant. This plant has indeed proved very easy to establish, but at the expense of most other plants. However, it does provide excellent cover for wildlife, and to some extent this species has become naturalised in this country, but introducing it to a new pond is a lost

opportunity to help our native flora. Rigid Hornwort (Ceratophyllum demersum), a UK native species, would have been a far better choice.

Now, I prefer to find plants by poking around the local ditches after a farmer has been along scooping them out. I rescue some plants and place them in a holding tank for a month or so just to make sure there's not an unwelcome plant popping out of the soil. Also, I have taken to raising plants from seed. I have bought some seeds, but others I have just collected from common plants in the local ditches. Purple Loosestrife, for instance.

Although native species are the best choice, not all native species are good for our pool. Some species have very tough or spiky roots. They could pierce the pond liner or injure a swimmers foot. Branded Bur-reed (Sparganium erectum), Norfolk Reed (Phyagmites australis), Bulrush (Typha latifolia) should be avoided.

Most information on planting Natural Swimming Pools gives the impression that planting-up the pool is a mystical art, requiring critical seasonal timing coupled with a scientific precison to measuring planting depths and weighted basket sizes. Most native floating-leaved and marginal plants are oblivious to this and are quite happy to be shoved into the substrate, at roughly the right water depth, anytime of year.

Fringed Water-lily
(Nymphoides peltata)

(Beware of plants from garden centres. There are some very aggressive non-native species that can be too dominant. Indeed, invasive alien plants are causing havoc in our countryside, some regretfully, have been introduced by gardeners. One big baddy, New Zealand Pigmyweed (Crassula helmsii) has been spread in garden centres and nurseries and is often present as seeds in the pots of other plants.)

A Selection of Native (UK) plants suitable for a wildlife pool.

Depth of water	Type of plant	Names	Comments
Dry areas adjacent to the pool.	Terrestrial wildflower plants.	Cow Parsley (Anthriscus sylvestris) Devil's-bit Scabious (Succisa pratensis) Hemp Agrimony (Eupatorium cannabinum) Teasel (Dipsacus fullonum), Purple loosestrife (Lythrum salicaria) Red Valerian (Centranthus ruber) Yarrow (Achillea millefolium)	A wildflower area near your pool will provide a habitat for amphibians, and the adult forms of some aquatic insects, like hoverflies, which will find nectar there.
Dry – 3 cm	Low-growing wetland grasses. Can be planted in dry ground, or a few cm of water.	Creeping Bent (Agrostis stolonifera) – which is often present as a lawn grass, but also likes dipping in water. Small sweet-grasses (Glyceria fluitans)	Creeping wetland grasses provide an excellent habitat for newts, water beetles and many other creatures.
2-10 cm	Marginal herbs and rushes that grow into the water.	Lesser Spearwort (Ranunculus flammula) Marsh Pennywort (Hydrocotyle vulgaris) Water Forget-me-not (Myosotis scorpioides) Water Mint (Mentha aquatica) Watercress (Rorippa nasturtium-aquaticum)	Where possible include marginal plants that can extend out into the water and provide a submerged habitat for animals.
2-10 cm	Marginal plants with attractive flowers and architecture.	Flowering Rush (Butomus umbellatus) Marsh Cinquefoil (Potentilla palustris) Marsh Woundwort (Stachys palustris) Marsh-marigold (Caltha palustris) Pendulous Sedge (Carex pendula) Purple Loosestrife (Lythrum salicaria) Ragged-robin (Lychnis flos-cuculi) Water Dock (Rumex hydrolapathum) Yellow Iris (Iris pseudacorus)	These native species are well adapted for planting on damp banks and in marsh areas.
2-10 cm	Tall emergent. Plant in 2-10 cm depth of water.	Greater Pond-sedge (Carex riparia) Hard Rush (Juncus inflexus) Lesser Reedmace (Typha angustifolia) Reed Sweet-grass (Glyceria maxima) Soft Rush (Juncus effusus)	Tall marginal plants are good for wildlife but some can come to dominate your pool so cut them back each winter.
15 cm-30 cm	Floating-leaved plants.	Amphibious Bistort (Persicaria amphibia) Broad-leaved Pondweed (Potamogeton natans) Fringed Water-lily (Nymphoides peltata) White Water-lily (Nymphaea alba) Yellow Water-lily (Nuphar lutea)	Amphibious Bistort and Broad-leaved Pondweed are easy to establish and they are extensively used by invertebrates.
30cm – deep water	Submerged plants. Float in deep water.	Common Water-starwort (Callitriche stagnalis) Curled Pondweed (Potamogeton crispus) Rigid Hornwort (Ceratophyllum demersum) Spiked water-milfoil (Myriophyllum spicatum) Water-crowfoot (Ranunculus aqualtilis)	Submerged plants can be tricky to get established, particularly if pond water quality is poor. (i.e. tap water). Only if all else fails try a non native like – Largarosiphon major

Plants for water purification

Any notion that the selection of pond plants suitable for water purification is critical, requiring professional judgement and strategic planting, will be dissolved away by these photographs of my water butt.

This neglected vessel, once full of cloudy green water, had become home to a clump of couch grass. As I pulled out the grass to fill a watering can, I was amazed to see the water had become deliciously clear. The grass had deprived the previously dominant single-celled algae of nutrients and light. It was this observation that started me thinking about cleaning pools with plants.

How the plants clean the water:

The zone of activity and interaction between plant, water and nutrients is a film of colloids surrounding the plant roots. Generally the surfaces of these colloids are negatively charged, so they will bind positively charged ions such as potassium and magnesium, present in the water. These positively charged ions are exchanged for hydrogen ions from the plant roots, making the nutrient elements available for the plant and removing them from the water.

Nyphae Alba is native to the UK. The root has a tendency to float so dig it in and weight it with a large stone or sandbag. Once it's established the weight can removed.

Planting Yellow flag iris (Iris pseudacorus), Marsh-marigold (Caltha palustris), Reed Sweet-grass (Gyceria maxima), Water Mint (Mentha aquatica).

The pond just filled. The water has a lot of suspended sediment from the subsoil substrate and gravel.

Connecting the air supply to the Pool

Connecting a 60W aquarium air compressor to the 15mm supply pipe that feed the pond pipework.

The filter bubbles into life, powered by the airflow from the compressor. The wooden lid for the filter is made from an old pallet.

5

Taking off lid, we see the water being pumped inside the filter with only the power of bubbles. The water level is low so we can see the flow from the pipe. Normally, the pipe terminates below the surface so we only see the gentle circulation of the water.

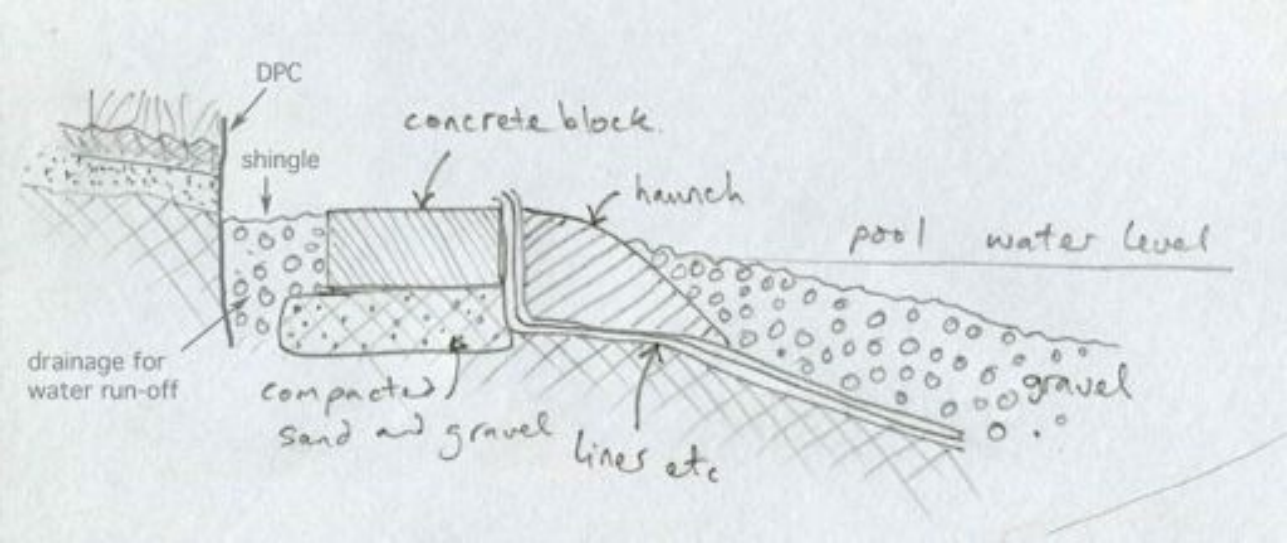
A week later and most of the sediment has settled or been filtered out. The measured flow rate through the barrel filter is around one litre per second; that's 3.6 cubic metres of water per hour. It could filter the entire pool contents in 10 hours.

The pool is already too tempting to resist.

The water has a slight brown tint, quite pleasant, sort of a weak tea quality – Earl Grey perhaps?

Eight months later, the water is clear. I have moved the fence further back, made a jetty over the filter and removed the architectural brutalism of the plank resting on concrete blocks.

FIN.



Making a Stronger Edge

After using the pool for a while I realised the edge on the beach side of the pool was not stable enough for the amount of trampling it was undergoing. I had some concrete blocks, which would make a simple path around that edge. I pulled out the pieces of insulation board I had used previously and dug a trench 12 inches wide 8 inches deep and around that edge. The bottom of the trench was stable subsoil so I didn't need to go any further down. Then, I partially filled the trench with 4 inches of sand and gravel and tamped it down to make a smooth bed. I simply placed the 4 by 10 inch thick blocks face down, in a line along this bed, resting them up against the layers of liner (underliner/liner/overliner) so as to keep the layers vertical at the edge. On the back side of the blocks, the space was filled with shingle to drain away water run-off from the surrounding grassy area. I also used some six-inch wide brick laying Damp Proof Course (DPC) membrane to keep the topsoil out of the shingle drain. Once all the blocks were laid, I brushed the whole path with sand.

To make the edge even more robust I mixed up some reasonably stiff concrete, (1 cement, 2 sand and 3 aggregate with not much water), cleared the gravel on the inside edge of the pool, and shovelled the concrete in its place. This made a haunch, keeping the liner layers firmly sandwiched together and vertical at the edge.

Just to recap, the (underliner/liner/overliner) needs to be vertical so the possibility of capillary action across the membranes is minimised.

I dug out a trench behind the pool edge. After leveling and compacting the ground I laid a line of concrete blocks to form a narrow path.

Pulling back the liner to show the insulation board I had used previously. Now, I realise it is not robust enough for the amount of trampling it gets so I'm removing it.

To make the edge properly robust, I mixed up some reasonably stiff concrete, (cement, sand and gravel with not much water), cleared the gravel on the inside edge of the pool, and shovelled the concrete in its place. This made a haunch; keeping the liner layers firmly sandwiched together and vertical at the edge.

Shovelling the concrete against the layers of liner.

I also, had prepared some loops made of tough rope to be buried in the haunch. The loop ends set to protrude out. I used these to help fix the oak sleepers on the gravel beach.

A loop appearing out of the concrete haunch.

The concrete has dried. The three layers of liner can be trimmed off with an old kitchen knife.

After the trim the edge of the liner is hardly visible.

The haunch finished. As you can see by the “join” in the concrete, I did it over a couple of days.

The shingle is pushed back to bury the haunch.

A loop poking up through the gravel ready to by used to help tether the oak sleepers in position.

A dowel tapped into the oak sleeper. It will be trimmed to a few inches long and hooked through one of the rope loops. This is an alternative to using concrete to fix the sleepers. And, of course these sleepers are just for looks so you don't need really them.

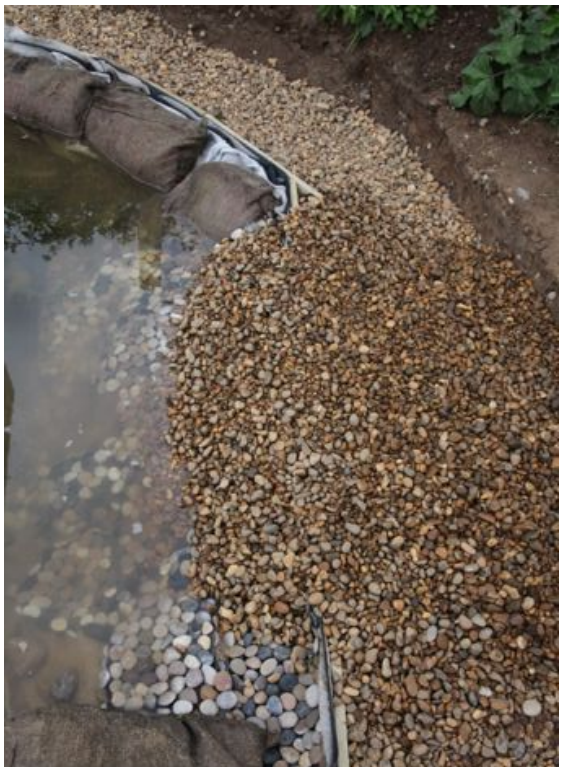
The edge is complete and dressed with larger stones.

Alternative Pond Edges.

The DPC strip is nailed to the pegs.

Making an edge with a roll of 150mm (6 in) wide bricklaying DPC (Damp Proof Course) membrane nailed to wooden pegs.

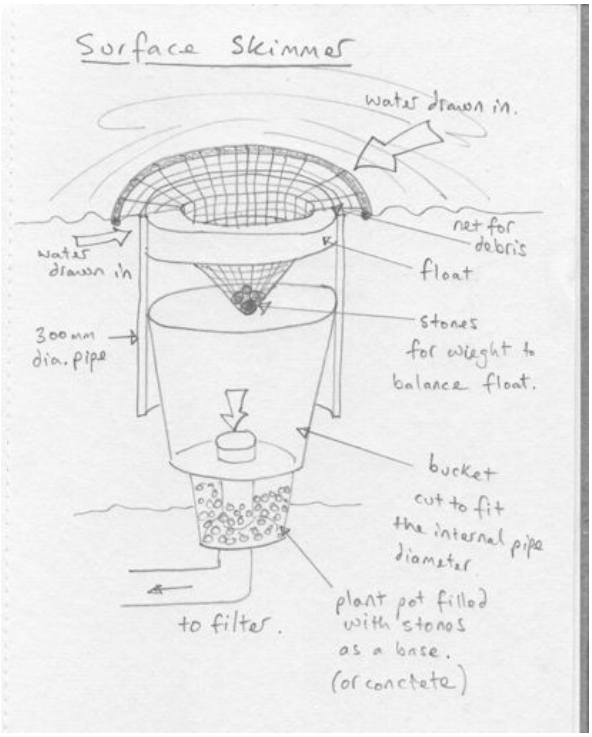
The pond liner/under/overliner can then stand vertically on the inside of this edge. To make it more robust, concrete can be haunched up either side of the DPC.

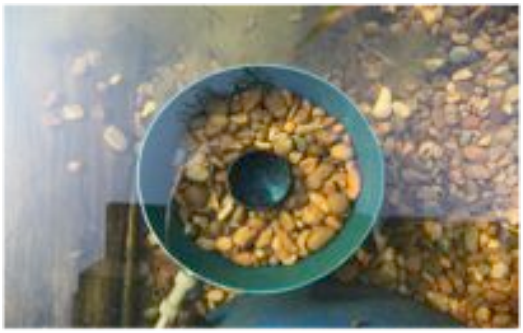


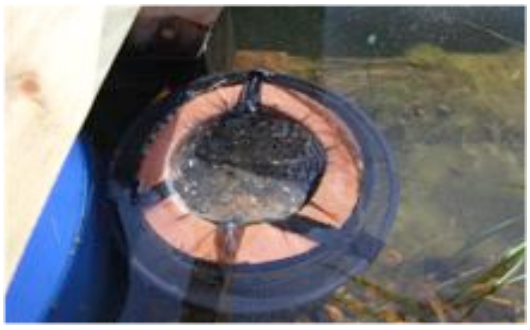
The whole lot is covered in gravel.

This is a small (3x3m) unfinished pond with the gravel beach at the far end.

Making a Surface Skimmer for the Filter


Surface Skimmer
water drawn in.
net for debris
water drawn in
float
300mm dia. pipe
stones for weight to balance float.
bucket cut to fit the internal pipe diameter
to filter.
plant pot filled with stones as a base. (or concrete)





This surface skimmer is made from a piece of pipe from a drain 300mm dia. (12 in). A bucket (green) has had the top cut off to match this internal diameter. As a bucket is slightly conical it can be cut to match a range of diameters. A 70mm dia. hole is cut in the base of the bucket for the 68mm pipe to come through. A float is jammed around the inner edge of the 300mm pipe – I used stuff from a life jacket. A child's crab net is draped over the top and stones added until it just floats on the surface. Then it is neutrally buoyant.

The filter is turned on, water is sucked through, and surface pollen dust collects in the skimmer. See this working on youtube - see appendix.

Making a Jetty

The filter barrel does look a bit bleak, so I thought a jetty would hide it nicely and make the filter easier to access.

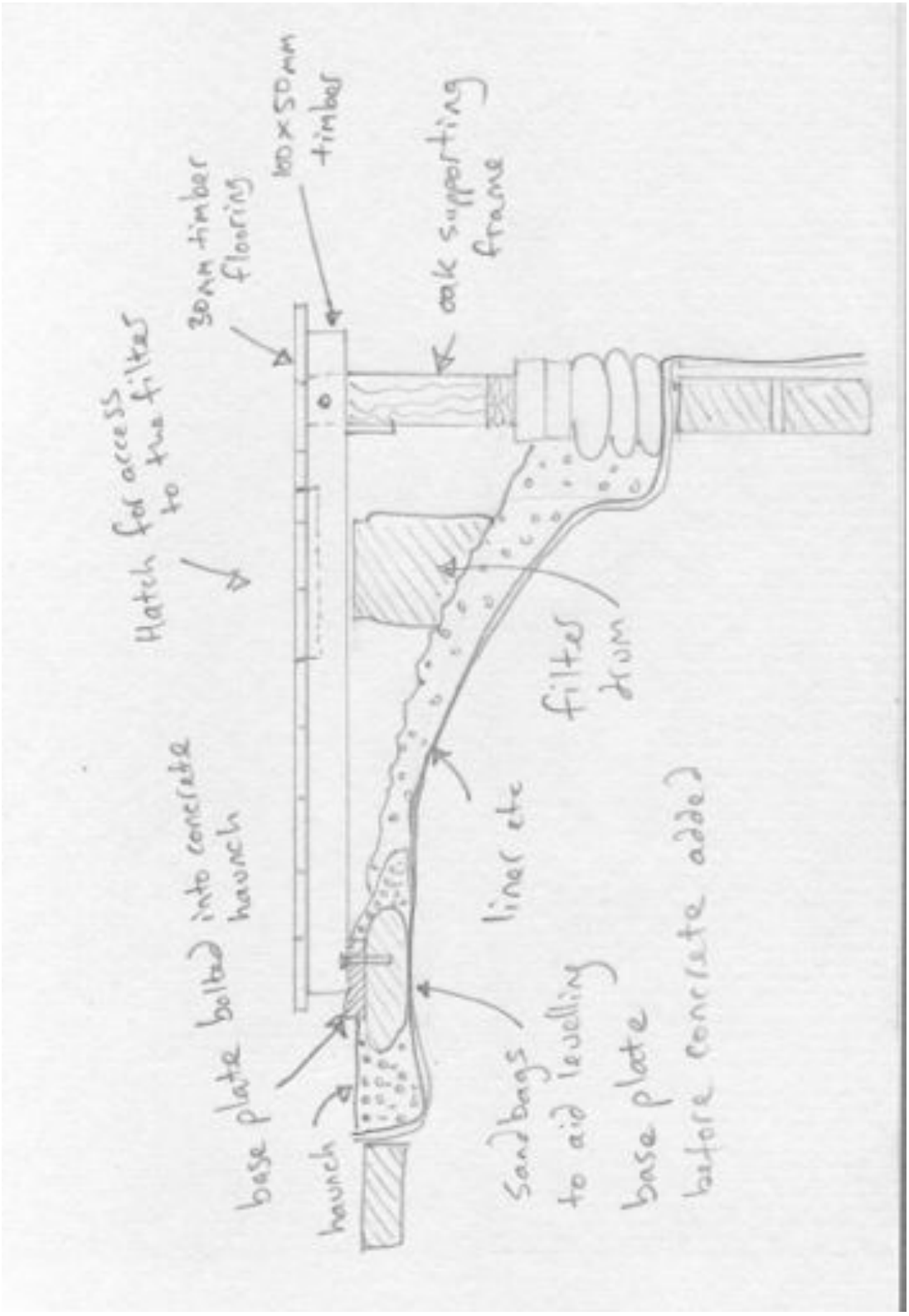
None of the following timber sizes are critical so just improvise with what you have to hand.

7 by 2.5 inch (180x70mm) oak and a few 4 inch by 1 inch (100x25mm) struts fixed together with dowels.

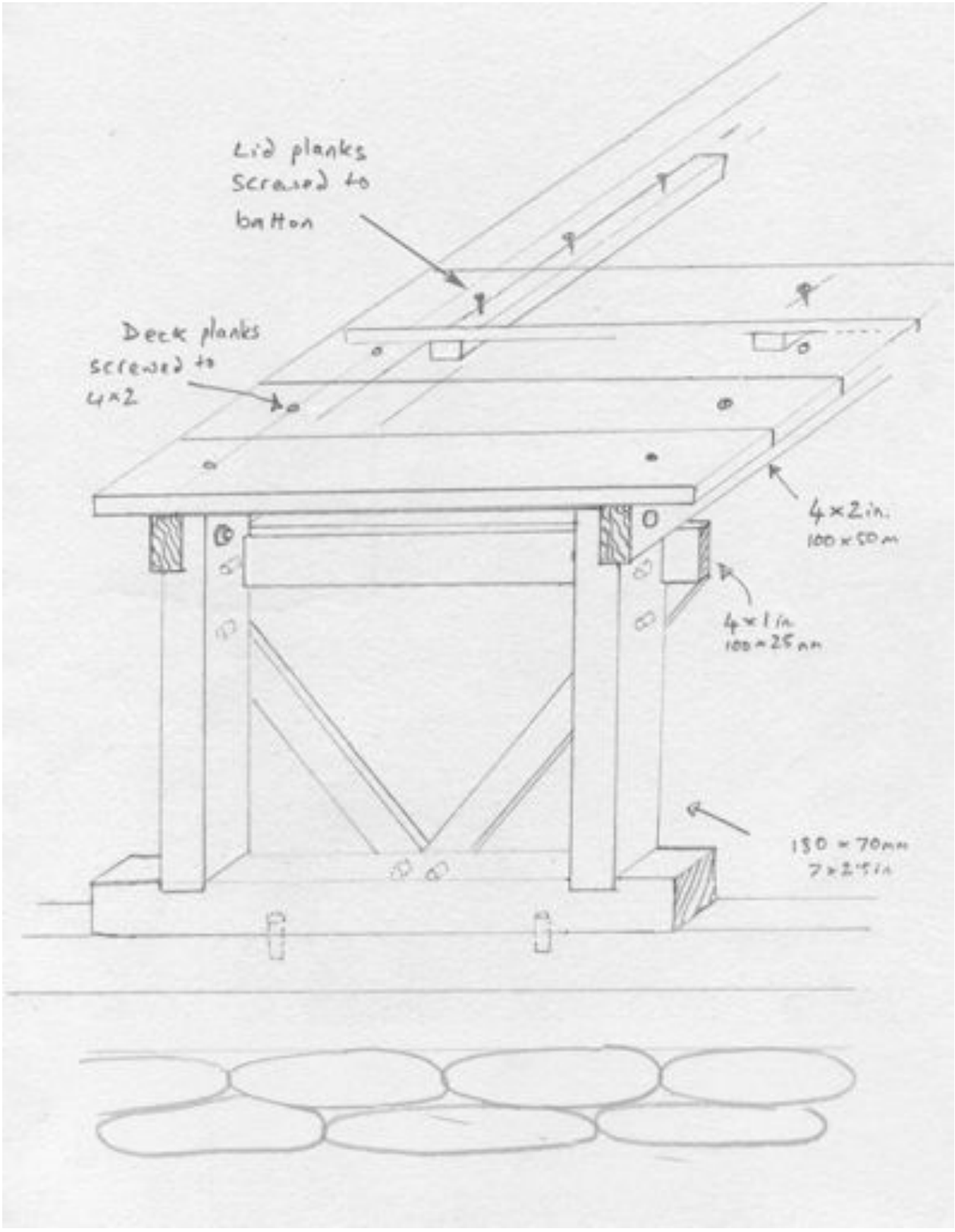
The frame has a 1m (3ft3in) wide base, which will rest on the oak sleepers on the pool's regeneration area separation wall. The two dowels stick out from the base to lock into a couple of holes in the sleepers.

The dowels are half inch diameter pieces of hardwood (taken from a scrap cot frame).

Dowels are easy and very satisfying to use. Cut a piece of dowel an inch longer than you need. Select a drill slightly narrower than your dowel. Drill your hole, bash in the dowel and then trim it off. You can show it even more affection by rubbing with sandpaper.



Cross-section of a simple 2m (78in) long jetty with a hatch for access to the filter.



The jetty showing the framework.

The frame is temporarily held in position. When the joist is adjusted to be horizontal, then the uprights on the frame are marked for notching and trimming.

One upright has been trimmed and a half inch deep notch is cut.

The notch is cut to key-in the 4x2 inch (100x50mm) horizontal jetty joist.

(If you make a longer jetty, then the joists need to be more substantial. 6x2 inch (150x50mm) joists are adequate for most situations.)

Drilling a 12mm hole to bolt the beam to the upright.

Clamping a spare piece of wood to make the drill's exit hole neater. It helps stop the wood splintering as the drill-bit goes through.

The 4 by 2 inch jetty beams are both bolted to the frame. (M12, 130mm) (0.5in. dia. 5.25in. long carriage bolts)

The land end of the jetty is resting on a 4 by 1 inch hard wood base plate. It is propped with sandbags to help level the frame.

For the decking I am using plain, untreated flooring pine. Treated timber contains copper fungicide – not good for pond life. The flooring comes with groves on the underside. I will use these face-up to make a non- slip surface.

The hardwood base plate has 50x50mm (2x2 in) piece of timber fixed to it and the jetty frame with a stainless steel threaded rod (M12, 250mm)(0.5in. dia. 10in. length) fitted through both. The rod has a nut and washer each end.

A concrete haunch envelopes the rod to permanently fix the base plate in position.

The jetty fixed in position and the decking finished.

The hatch lifted to have a look at the filter.

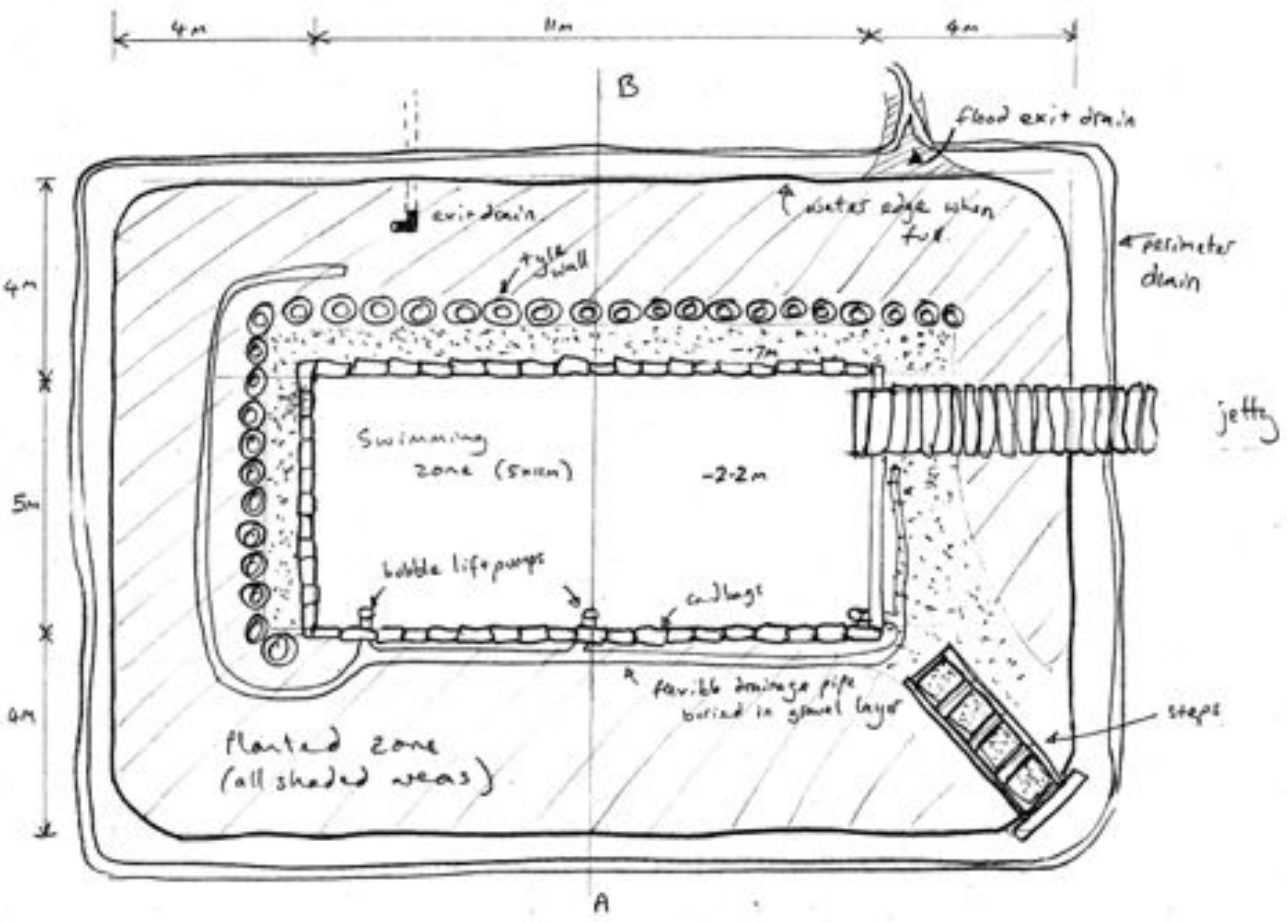
Making a Large Organic Pool

The Organic Pool (Natural Swimming Pool or Swimming Pond – the same thing) is divided into two equal area zones; one zone for plants, the regeneration zone, and one zone for swimming. The plants have only sand or gravel to grow in so their only chance of getting nutrients is to take it from the water. Then hopefully the algae, like blanket weed, have little left to feed on, so they don't become a problem.

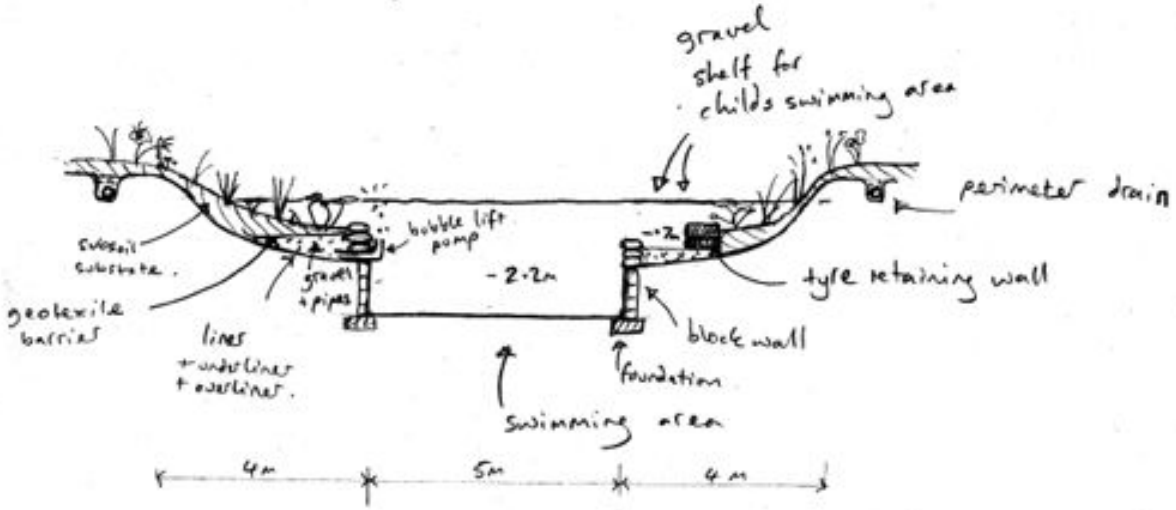
The regeneration zone is separated from the swimming zone by a submerged wall. This is to stop the plants colonising the whole pool. In this pool the swimming zone is at the centre of the pool.

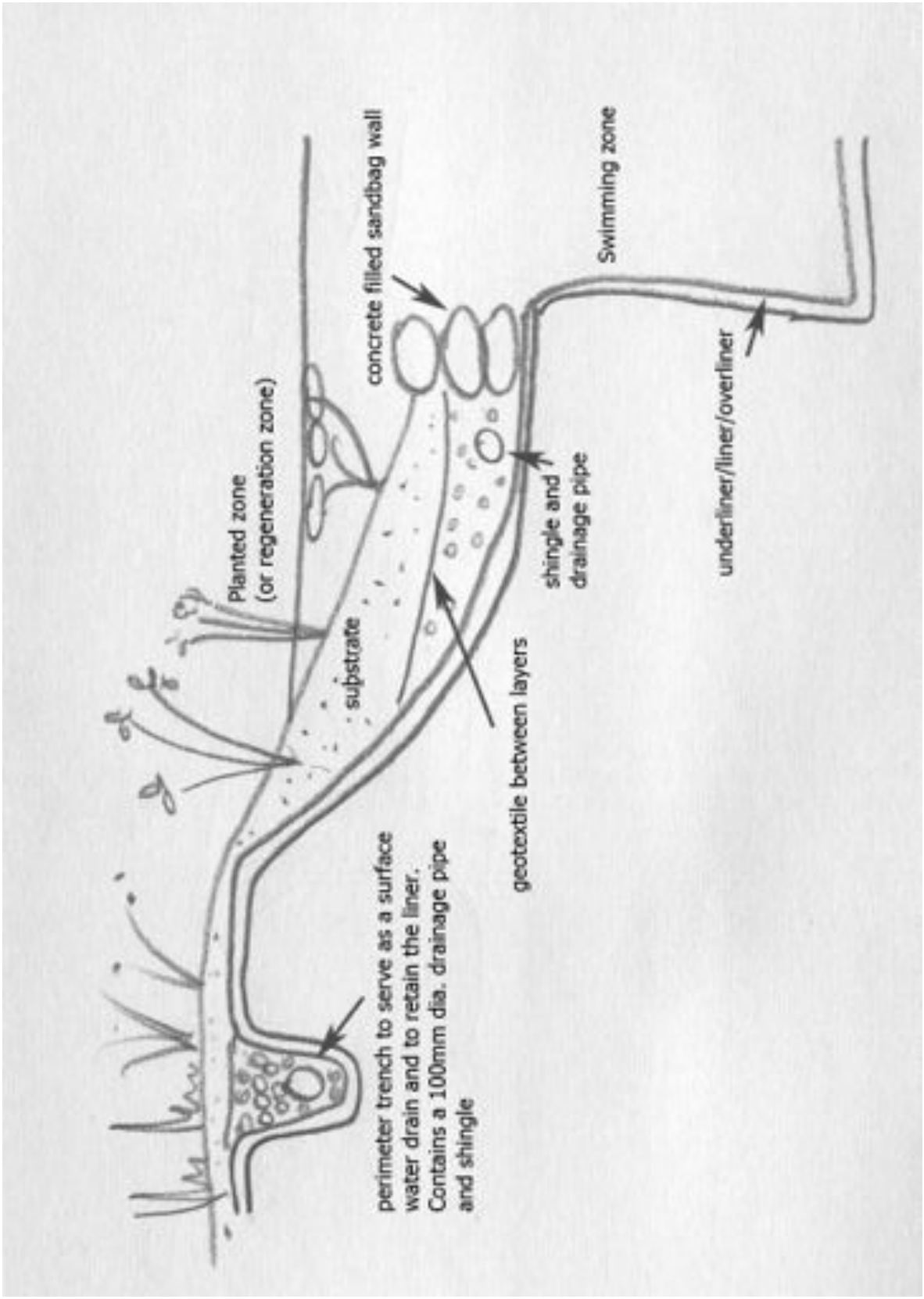
I decided on a swimming area of 4.5 m by 11.5m, about 2.2m deep, with a shallow 3 m wide regeneration zone all around it. I needed an area roughly 20m by 15m. I chose one corner of the field sheltered by a bramble filled bund. I could also have it aligned north-south, forming a pleasant sun trap at the south side against the bund.

plan of my Larger pool.



cross section through AB.





Cross-section of the edge and the panted zone. This method of making the edge requires more liner but less building work.

Digging a Large Hole.

The whole site of the pool is cleared of topsoil and stored in heaps no higher than one metre to help prevent it compressing and losing structure. Once the topsoil has been removed then we can start digging. The deepest part of the excavation should be tackled first, the swimming zone. The digging should be done by working from the centre outwards so the digger arm will be able to reach all parts of the excavation. The swimming zone is less than five metres wide and accessible from both sides, which means that a standard JCB backhoe can comfortably reach all parts of the excavation.

The subsoil dug from the hole can be used straight away to build up banks or heaped nearby for later use. If the subsoil is unsuitable for use on the project it will have to be disposed of somehow. Filling your trousers and staggering out for eye-watering walks is one fossil-fuel-free option.

The photo above shows the beginnings of a sandbag wall, which was a complete waste of effort. My original intention was to build the wall from sandbags filled with sand and clay from the hole. But this was a disaster. When it rained the bags became squidgy, started slithering and slumping until the wall gently collapsed. I tried again, this time filling them with clean sand. These were more stable but after a while the sunlight started to turn the synthetic sandbag material into something no harder than tissue paper. They split, the sand trickled out and the wall duly collapsed again.

Don't do this.

Do this. Sit down and ponder. I reluctantly had to start again, this time digging out some foundations for a concrete block wall. I flung the sand from the sandbags into the mixer to make the concrete for the foundation.

The simplest and lowest energy solution to creating the desired shape for the pool would be to carefully sculpt the subsoil. This would require stable subsoil, capable of being cut to form one metre vertical walls, and a reliable rain-free period to stop your creation turning to slush. Here in the UK the weather is usually not predicable enough for this to be an option.

Smoothing the concrete foundation.

The soil on this site contains some clay but is mainly stony and sandy. But importantly, the land is free draining. This meant I could lay the liner (with an under-liner) directly on the pond subsoil floor. If it had been a waterlogged site then the floor would have to be concreted over to stop ground water coming up and 'floating' the liner in a completed pond. Or a gravel soak-away made under the pool draining ground water into a sump and then pumped away.

The first rows of blocks are going down.

Aim to get a row completed all the way round as soon as possible.

Even if it's just one block high it is much more weather resistant. If it rains, slurry from the subsoil just builds up behind the wall and is kept out of the central working area.

The walls are built up to five blocks high,

Halfway along the long walls I incorporated blocks perpendicular to the wall to project back and form a strong "key" into the bank. Rubble and spare mortar or concrete from each day's work was tipped in to encase it.

Polystyrene (50x2400x1200mm) insulation panels have been placed behind the wall. (In house building, to improve the effectiveness of the insulation, a damp proof membrane is placed between the insulation and the ground. Here that is impractical).

The void behind the wall (and insulation) was packed with sand and rammed with a tamper, left to settle, and rammed again over a period of weeks. This was to make sure the outward pressure of the water was not going to push the wall over.

A channel 300mm (12in) deep and wide has been dug around the perimeter of the pool. This will retain the layers of liner and hold a perforated drainage pipe and gravel to form a curtain drain. This will divert surface run-off water from entering the pool.

The pool has been raked over to take out stones and smoothed. Then compacted with a petrol-driven “Wacker” plate.

The first sheet of underliner geotextile (Polyfelt) is draped from the channel on the perimeter and down the swimming zone.

The underliner is almost completed. The base of the swimming zone has been covered in a black gardening geo-textile because it is cheaper than the Polyfelt. However, the liner will be protected by the insulation that will be laid on top of this.

Here, the swimming zone is halfway through being completely covered in 25mm (1in) thick insulation boards (1200x2400mm, 8x4ft, Celotex).

My greatest expense was the pond liner. It was also one of the hardest purchasing decisions. There is so much conflicting advice around, a lot of it from manufacturers claiming there is product superior. Pond liners come in various thicknesses and materials. A thicker liner is obviously stronger and more expensive but it is also heavier to manipulate. I opted for 0.75mm thick EPDM. Although I think this was more a random choice born from a frustration of indecision. It seems to hold water, so not a bad decision in the end. The edge of the liner was going to be buried in shingle contained in a foot deep ditch around the perimeter of the pond, and formed into a curtain drain. This keeps water run-off from the field from entering the pond and introducing nutrients, which would encourage algae. So, taking this into account, I needed a liner, 26m by 20m. It cost £2,300 – the most expensive bit of plastic I have ever bought.

The liner is very heavy and awkward to manipulate. Once the roll starts unwinding it takes considerable effort to stop it from unwinding itself. We used a fence post to move the liner in “ripples”.

The roll of liner is 485kg. Even the short loops we are dragging are heavy.

Some smooth sand is about to be used to fill any small gaps between the insulation panels in the swimming zone and brushed into the edges to soften the corners a little. The liner is unrolled but there is a problem – it's too short.

It transpires the liner was rolled the wrong way in the factory, so I had to rotate it 90 degrees. Easier said than done. It now lays from side to side.

Pulling out the first half of the liner. The liner is 0.75mm thick EPDM. As the liner is so large I chose this thickness as a compromise. A thicker liner, say 1mm, is more robust but would have been heavier and even more difficult to manoeuvre.

The liner was pulled out in stages. This involved a lot of frantic up and down arm waving to waft air under the liner. This made it "float" momentarily. It could then be pulled out as the trapped air travelled in pulses towards the middle. Have a look at my You tube video.

The liner has been pulled out over all the pool. This is an exhausting job. Get as many people as you can to help. Bribe them with beer and cake.

The liner has been unfurled and held in position with sandbags in the perimeter channel.

In the swimming zone the liner has been smoothed out and mitre folded in the corners. A row of sandbags containing a dry mix of weak concrete (roughly- 1 cement, 4 sand, 4 aggregate) firmly holds the liner.

Rows of tyres are being used to create a retaining wall for the bulk of the substrate that will be piled up behind it. This would not be needed if the pool contour had been made less steep.

Flexible perforated drainage pipes are in position. They will soon be within a layer of gravel to help draw water from under the planted zone and into the swimming zone.

These drainage pipes connect up to the bubble pumps to provide the circulation through the planted zone.

The flexible perforated drainage pipes covered in a layer of shingle.

The layer of shingle covers the flexible pipes. Geotextile (black gardening) will cover this shingle layer.

The substrate, (sandy subsoil) has been spread all over the outer areas of the pool. The gravel beds containing the flexible pipes have been covered in geotextile and then the substrate. As the pool is being worked on, rainfall is filling the pool.

The curtain drain loops around the pool and is channeled out through the bank.

(The third pipe on top is a 110mm drainpipe from the flood drain used if the water level gets up to the rim in a flash rainfall – but this has never been needed).

A layer of ordinary black gardening geotextile is put over the gravel areas and covered in substrate (sandy subsoil). Here the perimeter drain is being covered. Note: This method of pool edge, although simple to construct, is prone to increased water loss due to capillary action from the overliner. If rainfall is low, use an alternative pool edging.

A chestnut paling fence keeps the pool out of bounds for children.

A layer of substrate is now spread all over the outer area of the pool.

The wall was effectively continued up with more sandbags to a height of around 40 cm (16 in). Each row of sandbags pushed back about an inch compared to the row below, making the wall lean outwards against the ballast it has to retain.

The wall of tyres is only needed because I dug the sides too steeply. A gentle 4:1 slope from the swimming zone to the pool edge would also have required far less initial digging and less substrate to be laid on back top.

The tyre wall retains the substrate (sandy subsoil) on the banks. (Later I became concerned that tyres may pollute the water with cadmium, so I had the water tested. The levels of cadmium were so low as to be almost immeasurable. Further to this, the range of tests performed showed the water quality exceeded UK drinking water standards.) However, I do not recommend using tyres. If the pool is made correctly with 30% slopes there is no need for them.

The substrate of sandy subsoil has been spread all over the outer area of the pool.

The pool is filling with rainwater and roof water being collected and pumped from the house.

See how the water quality has changed. Single-celled algae are making the water opaque. Don't panic.

I have planted flag iris, which are beginning to come up around the pool. The water is beginning to clear as the plants develop.

Water lilies are dotted around the pool in the deeper areas of the regeneration zone.

A jetty is taking shape. The main beams are 3.2m 150x50mm (6x2in) timber supported on an oak frame. Today, the water is looking cloudy. As the pool biology matures is will go through some unsightly phases. Rather like a teenager. When the chemistry settles, all will become clear.

Fish weed, Largarosiphon major, although too rampant, is doing an excellent job of depriving algae of nutrients. However, I recommend only using native oxygenating plants.

The marsh marigolds, iris and lilies are getting established. Most of the pond and the banks I have just left for wild plants to colonise.

As the ecology of micro-organisms in the pool matures, the water becomes clearer.

Animals.

The pool will become home to a great variety of animals but none of them should be introduced. Incidentally, it is often cited that frogs are a good biological indicator for healthy water, low in pollutants. This is not true. Frogs are not particularly fussy when it comes to dirty water, or as we see above, selecting a mate. The toad doesn't seem to mind either.

Fish

It may be very tempting to have fish in the pool but they are usually planktivores and will devour our precious daphnia and leave the pool vulnerable to algae. Even if the fish is a herbivore, like carp, it will cause mayhem pulling up plants and stirring up sediments.

Ducks

Ducks can be destructive to the plants but more importantly they may carry a pathogen, which causes swimming dermatitis. The pathogen is a cercary, a small fork-tailed larve of trematode worms of the genus Trichobilharzia which normally affects birds and their intermediate hosts, snails. Humans are accidental hosts, which are mistakenly sought out by the cercaries. The cercaries are killed off by the skin's immune defence but they may cause itching. It is not dangerous and its effects are not long lasting but it is best to take measures to avoid it.

Cercaries can only develop in environments where there are sufficient numbers of snails as the intermediate hosts and waterfowl as the end hosts. So keep ducks away and if there are lots of snails, remove some regularly. You will also helping to reduce overall nutrient levels in the pool in the process.

Appendix

Embodied Energy calculation for the construction materials. (Imperial units)

	Liner	Cement	Concrete blocks	Wood	Sand and gravel
BTU/lb	18,500	4,100	940	185	18
Weight (lbs)	500	400	5,000	1,600	20,000
BTU	~10,000,000	1,600,000	~5,000,000	320,000	360,000

The pool liner has the biggest Embodied Energy requirement. Reducing the amount of concrete used in the build has helped control the total energy needed.

The letter with water test results for the large pool.

Dear David,

Thank you very much for speaking with me earlier regarding your water test results. The water complies with the UK drinking water standards in that all parameters tested fall within the maximum limits laid down by the water standards regulatory body.

Biology was good with none from a specific list including the coliform, (E-coli, clostridia etc) families. General non specific biology tipped the scales at >300 on the 2-3 day petri dish incubator test meaning that the concentration found exceeded the ability of the instrument to measure it. This isn't surprising, given that it's healthy pond water. I would be happy to drink your water as it is right from the pond.

Everything in the sample results indicate that you have a happy mini eco system going on there.

South Coast Water

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Water Garden, Philip Swindells, Salamander

My films and photos:

organicpools.co.uk

youtube.com/organicpools

facebook.com/organicpools

twitter.com/organicpools

David Pagan Butler has been a pond obsessive all his life but has only recently realised its significance. The turning point happened in 2005 after discovering a sod of couch grass growing in a neglected water-butt. The observation of clear water lurking beneath the matt of roots propelled him to build a one hundred and eighty square metre swimming pool without any instructions or advice or even a clear idea of what he was going to end up with other than it would be full of plants and free of chemicals.

Isolated through digging in his hole for so long, he was oblivious to the fact that Natural Swimming Pools had already been invented, twenty years before, but when he finally emerged from his bubble, he had created not only a beautiful pool, but a pool that was quite unique. In a process akin to parallel evolution, he had re-invented the Natural Swimming Pool, but his pool was very different, it was low energy, affordable, a wildlife haven, full of bubbles and bubble powered devices and along with the multitude of pond plants, almost inexplicably, the shallows were left to run wild with couch-grass.

David is amongst other things, a filmmaker. It was while making a film for the BBC on Natural Swimming Pools he met Peter Petriech, one of the pioneers. They talked pond stuff for hours. David has now devoted most of his waking time to comunnicating the wonders of these pools, through film, radio, newspaper, magazine articles and now, this manual.

More Tea Please.

If you after all of this you're eager to learn more then you could come to one of my courses and talk pond stuff and drink loads of tea.

I'll have details on my website:

www.organicpools.co.uk

I have also produced a DVD of these projects to accompany this manual:

Natural Swimming Pools, A Guide to Building Your Own, DVD, David Pagan Butler, Permanent Publications

Available from organicpools.co.uk

Let's dig ponds back into our landscape!

David Pagan Butler

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